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Telephone : Colmore 4274-4275 Telegrams : CIRA
The B.C.I.R.A. Scottish Laboratories are :—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone : 332

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Research in Wartime

It is true to state that much of the research work undertaken under normal conditions is the reinforcement by experiment of some personally-held theoretical concept. Occasionally, this is productive of much good, but there are cases on record where, apart from wastage of time and material, the outcome has been the production of the one-track mind. It is somewhat difficult for a research worker to have an entirely open mind, for usually he is faced with a research programme, formulated by either his professor or a committee. Probably in the older universities more freedom is obtainable by the research worker to follow his own bent.

Wartime conditions place the research worker on a new footing, as generally speaking his efforts have to be directed into one of two channels. First, he is called upon to create methods for the economical utilisation of materials which are in abundant supply, leaving those which increased consumption has rendered scarce to be used for the most urgent needs. The second call upon the research worker is the simplification and speeding up of manufacturing methods. For example, such processes as the malleablisation of white cast iron and case-hardening methods are obviously time-consuming, and their speeding up or replacement by quicker methods is a profitable field for investigation.

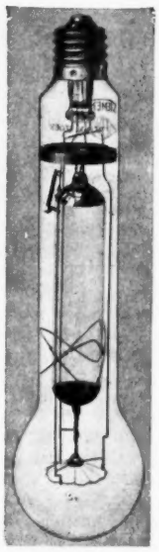
There is a good deal of loose talk in industry around the general question of the utilisation of alternative materials, especially the use of cast iron in the place of steel. The defence authorities are adamant in their insistence that a "dud" shell or bomb may cause a major disaster, and nothing but material of highest quality will satisfy. It cannot be said, however, that they are unreceptive to new ideas and methods, and it is for the research workers of the iron industry to bring proofs of their ability regularly to produce castings which can be relied upon to function satisfactorily under the most exacting tests. Books and data are available which set out in plain English just what almost any grade of material used for castings is capable of performing, and it is the duty of the ironfoundry industry to see that those in control of defence ministries are in possession of the latest facts. Delegations from the ironfounding industry which stress the magnitude of the unemployed capacity of the light-castings section will make as much impression as the salesman who tackles the buyer by asking him to "give him a start with his order-book." The Ministries need "selling" just as much as any buyer for a private concern and it is just here where the aid of the research worker, or better still the development officer, should be invoked.

There should be a better realisation of the fact that the great research laboratories created by industrial enterprise are busy tackling some immediate production problems, and the fundamental work normally undertaken has to go by the board. Moreover, no doubt problems are arising of which solutions are sought, but postponement has to be made. In these cases, manufacturers and their executives should not hesitate to consult the many existing organisations, the special object of which is the helping along of industry. Whilst these associations are busy, their directorates are sufficiently alive to the needs of the nation to change the programmes they have arranged for their research staff. We are by no means satisfied that the Government Departments or the large industrial concerns are utilising to the full the unquestionably great resources for research into wartime problems afforded not only by the co-operative organisations, but by those sponsored by parties interested in widening the consumption of the various basic metals. It is obvious to us from the inquiries we receive from the Ministries that the foundry industry and its suppliers invariably await the receipt of a *questionnaire*, rather than anticipate matters by sending in a short statement of their activities, potentialities and requirements, which in many cases would be a better course to pursue.

For example, it is difficult for the Ministries, often working in more or less watertight compartments, to realise the relative importance of commodities to activities other than their own immediate needs. It probably came as a slight shock to the Ministry of Food to find that the foundry industry required quite considerable tonnages of material for coremaking which happen to be edible. The cereal binders provide a case in point. As industrial concerns are too busy to think of such matters, then the development side of research should be so organised as to provide the Ministries with such information—not necessarily quantitative—in order to reduce delays. Reliance is still being placed by the Ministries on the technical Press for the supply of such information, and for our own part we cannot help but think that the time is long overdue for the suppliers to the foundry industry and the more specialised branches of the trade to inform the Ministries, rather than await questioning of the nature of their work.

New Lamp for Foundry Illumination

The "Sieray-Dual" lamp, details of which have been sent to us by Siemens Electric Lamps & Supplies, Limited, of 38-39, Upper Thames Street, London, E.C.4, possesses several unique characteristics of distinct interest to foundry executives. It differs from other types of electric-discharge lamp in that no choke or condenser is necessary for its operation, and the light emitted is of a pleasing colour.



With the elimination of the choke and condenser no alteration to existing wiring is necessary, and the "Sieray-Dual" lamp can be screwed into an ordinary Goliath holder to operate direct off the supply mains.

As will be seen from our illustration, the lamp consists essentially of a mercury vapour discharge lamp connected in series with a tungsten filament, the normal tubular outer bulb of the discharge lamp being expanded at its lower end to accommodate the filament. The tungsten filament serves not only to stabilise the arc of the discharge, thus replacing the usual choke coil, but, operating at its normal efficiency, also acts as a supplementary light source emitting light in which a considerable proportion of red rays is present. The deficiency in red rays from the discharge tube is thereby rectified, the resultant light being of a very pleasing colour.

Undue overloading of the tungsten filament at switching on is obviated by the provision of an auxiliary filament which is automatically switched out of circuit by means of a thermal cut-out at a pre-determined time in the run-up characteristic of the discharge tube. The arc of the discharge being stabilised by a resistance (the tungsten filament), the power factor of the circuit is not upset as with choke control, consequently the use of a condenser in the circuit is not required, the power factor of the "Sieray-Dual" lamp being approximately 0.95.

Immediately the lamp is switched on, a considerable amount of illumination is obtained, and after about 10 mins. the lamp reaches its full luminous output, with both the filament and discharge operating at their correct efficiencies. These lamps must only be installed cap-up in the vertical position.

The "Sieray-Dual" lamp is available in sizes with total consumptions rated at 300 watts and 500 watts in the case of A.C. lamps and 500 watts for use on D.C. supplies. The electric discharge tubes and tungsten filaments incorporated in the lamps operate at the normal efficiencies of their respective ratings. The bulk of the light is emitted from the highly-efficient discharge tube, whilst the light from the tungsten filament is usefully employed to build up the total lumens output of the lamp and also to rectify the shortage of red rays in the light emitted by the discharge tube, the resultant light from "Sieray-Dual" lamps containing approximately 8 per cent. of red rays.

The 300-watt "Sieray-Dual" lamp gives approximately 33⅓ per cent. more light than does a 300-watt gasfilled lamp, and the 500-watt lamp approximately 50 per cent. more than a 500-watt gasfilled lamp. The lamps are guaranteed to give an average life of 1,500 hrs.' burning, when properly installed.

U.S. Electric-Furnace Steel Capacity

RECENT INSTALLATIONS

The expansion of electric furnace capacity of the United States for the manufacture of quality steels may be raised as much as 450,000 tons this year, in view of additional capacity now being completed or contemplated, reports "Iron Age." The Republic Steel Corporation is to instal two 50-ton electric furnaces at its works at Canton, Ohio, which will give the concern a total equipment of three electric furnaces of 50-ton capacity, three of 25-ton capacity, three of 15-ton capacity, and two of 6-ton capacity. At the beginning of this year Republic announced a total capacity of 190,000 net tons, at which time the Timken Roller Bearing Company was in the lead with an annual capacity of 252,000 net tons. Although the Bethlehem Steel Company has made no official announcement regarding its electric furnace expansion, it is known that two furnaces of 56-ton capacity are being installed, which will give Bethlehem a total capacity of about 150,000 net tons. The Crucible Steel Company of America recently announced that it has completed installation of one 35-ton furnace at its Midland, Pa., works, and was installing another of the same size. Estimated increase in the total electric furnace capacity this year includes the new alloy steel plant of the Copperweld Steel Company at Warren, Ohio, with a capacity of about 100,000 tons annually.

As at December 31, 1939, electric furnace melting capacity for steel ingots was estimated by the American Iron and Steel Institute at 1,592,080 net tons. At the end of 1937, the total capacity was 1,223,716 tons, making an expansion of 368,364 tons in that period. This year's expansion will probably be the greatest the industry has experienced within a 12-month period.

Record Production Approached

The highest production of electric furnace alloy steel in any one year was 1,065,603 net tons in 1929, but this was closely approximated in 1939, when total production was 1,029,067 tons. Output of stainless steel ingots in 1939 was 179,620 tons. Not all of the electric furnace melting capacity is used for alloy steels, since one of the largest capacities is that of the Northwestern Steel & Wire Company, Sterling, Ill., amounting to 201,600 net tons annually, which is used for the conversion of scrap into carbon steel ingots for the manufacture of wire products.

The expansion of capacity is largely for alloy steels such as are used and will be used in the making of armour plate for tanks, steel for aeroplane parts, for the automobile industry, and for machine tool builders. Stainless steel requirements are very heavy and will expand under the stimulus of the U.S. defence programme.

(*Continued from next column.*)

creasing its machinability without in any way affecting its corrosion resistance and with scarcely an adverse effect on its mechanical properties. Selenium-bearing stainless steels are usually supplied in the form of bars rather than as sheets. Selenium is also being used in certain copper-alloy bearing metals.

The principal sources of the selenides or ores of selenium are Sweden, Germany, Argentina, Mexico, the United States, China, and Spain. Mexico, in particular, is a prolific source of selenides.

Selenium

PROPERTIES AND USES

Although selenium occurs in many different parts of the earth, it is never found in large deposits. MR. L. SANDERSON, in an article on the subject in "Canadian Mining Journal," states that it is not usually found in the native condition, the closest approximation of this being in an ore from Honduras which contains 29.31 per cent. of selenium. Volcanic sulphurs such as those of the Lipari Islands contain it; it has been found in gold ores, copper pyrites, in lead and mercury ores in Germany, in galena, bismuth ores, pitchblende, molybdenite, tellurium ores, etc. It occurs in Belgian coal, in Yorkshire coke, and in a number of other substances.

Selenium is usually extracted from the flue dust or chamber deposits occurring when pyrites containing selenium is burned in the production of sulphuric acid. It has an atomic weight of 79.2 (O = 16). It resembles sulphur in that it possesses a number of allotropic forms. For a long time controversy centred on the actual number of allotropic forms that could clearly be distinguished, but it now appears clear from the available evidence that there are only three in all. One cannot be dissolved in carbon disulphide, is of crystalline type, and composed of grey, metallic trigonal crystals. The second can be dissolved in carbon disulphide, is liquid, amorphous, of glassy character or colloidal. The third is also soluble, but is made up of reddish monoclinic crystals. This third variety is itself divisible into two types, one isomorphous with sulphur, the other not.

A piece of selenium of the second form when cooled down to about 30 deg. and broken has all the conchoidal appearance of broken glass so far as the form of the fracture is concerned. This type of selenium is frequently known as commercial or vitreous selenium. The specific gravity of 4.47 to 4.80, according to the particular form, the vitreous being represented by the first figure, and the metallic by the second. Monoclinic selenium has a specific gravity of 4.47. The hardness is 2.0 Moh. Thermal conductivity is small, and in the vitreous form, it is a non-conductor of electricity, but in the metallic form, it will conduct.

Light increases the electrical conductivity of selenium, which means that an illuminated fragment will transmit an electrical impulse more freely than a non-illuminated fragment. The increased conductivity is, however, primarily a surface phenomenon, and the rate of increase steadily lessens in proportion as one approaches the interior of the mineral. The selenium cell gives facility for the conversion of light into electrical energy. The photo-electric cell, as it is called, is employed to-day in an ever-widening range of instruments and for a vast number of purposes. In combination with a relay, it can be used for starting and stopping motors and for numerous other operations.

There are, however, other uses for selenium of some economic importance. It is used to some extent as a colouring medium for glazes, glasses, and enamels, giving a fine crimson hue. It is employed in the manufacture of flame-resisting insulated electric wires, paper, and the like. In colloidal form it is stated to be a wood preserver and also a germicide, fungicide, and insecticide. Probably the most recent development is the use of selenium as an ingredient in stainless austenitic nickel-chromium steels designed to withstand corrosion. One limiting factor in the use of these steels is their property of work-hardening. It has now been found that the addition of a small percentage of selenium to chromium-nickel steel has the effect of in-

(*Continued at foot of previous column.*)

Research and Developments in Cast Metals*

By C. H. LORIG

DEVELOPMENTS IN CAST STEEL

The technical and industrial developments leading up to the present status of the low-alloy, high yield-strength structural steels have had a profound effect in the steel castings industry as well. Low-alloy, high-strength cast steels have been developed in the past few years to provide for a combination of properties of castings in the normalised state to meet the following specifications: Tensile, 40 tons per sq. in. min., yield 26 tons per sq. in. min., elongation 22 per cent. min., and reduction of area 45 per cent. min. The trend in design for railway equipment is towards lightening the weight of existing structures without any sacrifice of strength.

Some Railway Alloy Steels

The three steels so far accepted by the railways are nickel-manganese, the manganese-vanadium, and the manganese-titanium types. Each contains from about 1.25 to 1.70 per cent. manganese. The average amounts of nickel, vanadium, and titanium added are 1.00 to 1.50 per cent. Ni, 0.10 per cent. V, and 0.05 per cent. Ti. These steels in the normalised condition and suitably tempered have the same properties, so that the choice between them depends on the practice and experiences of the individual foundries. Considerable tonnages of side frame, bolster, coupler, and other castings have been put to test on railways. Substantial savings in weight have been effected.

These new steels and the lightening of the structures have introduced many problems in design and casting technique. The reduction in section has greatly increased the importance of casting defects and has placed a premium on more perfect castings. Some of the difficulties are successfully being overcome by better supervision of melting, pouring, moulding, and sand technique; yet there is still much to be done towards perfecting the surface and eliminating the so-called stress raisers in the castings.

Aeroplane Landing Gear

Finlayson[1] of the Pacific Car & Foundry Company recently described the use of steel castings in landing-gear assemblies in the construction of giant transports of the most modern design. Here was an application for steel castings that required a careful scrutiny in the art of casting before the castings could be made successfully. The chemical and physical requirements for the steel in the castings were not difficult to satisfy. However, any form of crack or shrink or discontinuity on the surface or within the castings caused them to be rejected. They were finally made of copper-silicon steel containing 0.12 to 0.20 per cent. C, 1.10 to 1.35 per cent. Mn, 1.0 to 1.25 per cent. Si, 1.50 to 2.0 per cent Cu. This alloy steel was said to have marked fluidity so that it was capable of running into thin sections without cold shuts. Dry-sand moulds were used exclusively in the production of the castings, special precautions being taken to secure adequate venting and core relief. The moulds were coated with a double wash of zirconium oxide which notably improved the surface.

The castings are subjected to the most thorough inspection at the foundry and again at the customer's plant when received. The customer examines them for cracks and other defects by Magnafluxing when received. After each part is machined it is pickled and cadmium plated, operations which innocently serve to reveal slag spots, spongy areas, and internal fissures exposed on machining. If no defects are discovered by this means the castings are again Magnafluxed. After this, some castings are X-rayed to discover internal cavities or shrinks. The number of accepted castings naturally falls far below the average commercial yield. That castings are being made for and are accepted by the aircraft industry is an indication of the marked refinements that are possible in casting technique. This development should be an inspiration to the steel casting industry since it paves the way to new applications for castings that formerly were outside their accepted sphere.

Steel Castings and Forgings

It should be remembered that castings have engineering values in their own right. In many uses of steel castings, as for instance where flow lines lead to failure, the lack of directional properties in the castings made them more enduring than forgings.

Centrifugal Cast Gears

A year ago Ford Motor Company first announced the successful casting of steel gear blanks in centrifugal dies. The method is now in regular production for all Ford lorry ring gear blanks and will be extended to full production of car ring gears and transmission cluster gears as quickly as the necessary equipment is completed. The advantages claimed for the gears made by the new method are greater strength, lighter weight, and faster production. The improved strength in the cut teeth, for example, is the direct result of the absence of all flow lines in the centrifugal castings. Thus the metal is equally strong in all directions and is not weakened by flow lines parallel to lines of greatest stress, a condition which exists in some forgings.

It is now being recognised that steel castings have an advantage over forgings on another score. The coarse grain structure of the casting seems to give it inherently greater resistance to gradual distortion at high temperature, *i.e.*, greater creep strength than forged material of the same composition. Work which Battelle and others have done on creep testing of such materials has indicated this superiority for the cast steels.

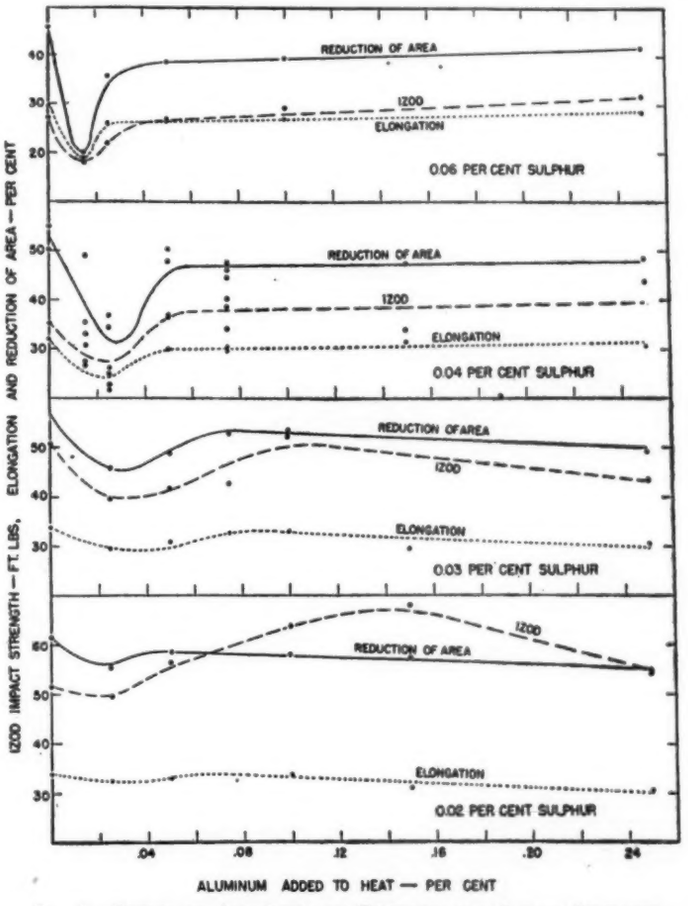


FIG. 1.—EFFECT OF ALUMINIUM ON DUCTILITY AND IMPACT STRENGTH OF GRADE "B" CAST STEELS.

Low Ductility Causes Discovered

The factors which lead to low ductility in cast steel are finally being discovered. The work of Sims and Lilliquist done at American Steel Foundries, the more recent work by Sims and Dahle at Battelle and the contributions of several other investigators have clarified the situation enormously. Low ductility is invariably associated with certain arrangements of non-metallics, especially manganese sulphide.

As a result of their work, Sims and co-workers reasoned that materials which may later form inclusions are in solution in liquid steel. A high oxygen content decreases the solvent power for these non-metallics and hence in the

* The second section of an address Mr. Lorig, supervising metallurgist, Battelle Memorial Institute, Columbus, Ohio, presented before the Cincinnati District Chapter of the American Foundrymen's Association. The first part of the author's Paper dealt with developments in cast iron.

presence of high oxygen they precipitate out of solution in the early stages of solidification and take the globular, harmless form. The solvent power of the steel for non-metallics increases as the liquid metal is more thoroughly deoxidised; under these conditions the non-metallics are held in solution till near the end of solidification and are then precipitated in the harmful network or eutectic form.

Sims and Dahle[3] found that with no aluminium the manganese sulphide inclusions are globular and not harmful. With small amounts of aluminium, sulphides are precipitated in a string-like or eutectic form, giving rise to a network in the steel and to low ductility. By using larger amounts of aluminium the aluminium sulphide type of inclusion is formed which again is less soluble in the steel and hence precipitates as harmless inclusions. Their results on the effect of aluminium on the ductility and impact strength of grade B steel of different sulphur contents are summarised in Fig. 1.

Recently Crafts[4] of Union Carbide and Carbon Laboratories has indicated that the ductility may be further augmented by the introduction of calcium with the aluminium.

"Spots" in Cast Steel

The occurrence of "spots," called fish-eyes in welds, in fractures of test-bars of cast steels is now receiving rather general consideration. These "spots" are attributed to hydrogen. They may appear, for example, when the steel is tested shortly after normalising. Long ageing at room temperature or short ageing at a moderately elevated temperature causes the spots to disappear and with their disappearance the ductility of the steel is profoundly improved. It seems that "spots" do not occur, for some unknown reason, in steels from every heat. So far as is known they have never caused a service failure; yet they may be responsible for many instances where test specimens fail to meet specifications for ductility. The same problem is being faced by the welding industry and to a lesser extent by the steel industry in general. As an expedient, low-temperature annealing is quite effective in removing "spots." A serious effort is now being made to study the factors involved in "spot" formation so as to minimise or prevent their occurrence.

Alloying and Heat-Treatment

In the last year or two mixtures have been developed for introducing various alloying elements into cast steel and iron that produce heat and cause the various alloys to melt immediately and disseminate in the metal without a decrease in temperature. This has made possible the extensive alloying of steels and irons in the ladle, and the introduction of alloys to the furnace without chilling the bath. The Chromium Mining & Smelting Company have conducted work at Battelle on this development for several years and are now actively engaged in commercialising the development by supplying the steel and castings industry with various alloying materials contained in a heat-producing mixture. Their various so-called "Chrom-X" mixtures are being employed in a number of foundries in the United States and Canada.

More emphasis has been given lately to the heat-treating of steel castings, with the result that castings even as large as 1½ tons are being water-quenched and tempered. The water quenching of castings is not new; yet the steel foundry has been very slow in realising its possibilities.

High-Temperature Effect on Sands

One might mention the progress made on investigating the effect of high temperatures on steel sands being done at Cornell University under the sponsorship of the American Foundrymen's Association. This work has shown that some sand mixtures are sensitive to heat-shock whereas others are not. Information gained from such tests should eventually be of direct interest to the steel castings industry in assisting to better the methods of compounding sand mixtures to meet the actual conditions that develop in the casting of molten metal.

DEVELOPMENTS IN MALLEABLE IRON

The malleable industry, as a whole, made little change in its product in the past quarter century. It is true that the general level of strength and ductility has been raised from time to time, but this was done mainly by lowering the carbon content without further altering the composition or the annealing practice. The only thing that might be done to change the properties of the fully malleablised iron is to alloy it, and this is done to a limited extent in a few plants.

Quick Anneal

A few foundries are producing short-cycle malleable, the quick anneal being accomplished by taking advantage of the accelerating effect of higher silicon and by using higher annealing temperatures. This calls for very careful supervision of the melting operation, a close control of raw materials, and vastly better annealing furnaces than the old box-type, batch furnaces in order to reap the full benefit from the possible reduction in annealing time. These quick-annealing irons have 2.0 to 2.20 per cent. carbon and 1.50 to 1.60 per cent. silicon, the manganese, sulphur and phosphorus being the same as in normal malleable. They can be fully malleablised in less than 24 hrs. in continuous furnaces with temperatures close to 980 deg. C. in the first stage of malleablisation.

Pearlitic Malleable

Various so-called pearlitic malleable irons are being marketed ranging in tensile strength from 27 to 54 tons per sq. in. These irons are being produced on a relatively small scale as yet, though it is possible their use will continue to increase as it has in the past. New combinations of properties are to be found in these irons.

There has been much interest in the low-carbon irons, or steels, as they are often called, of the Ford crankshaft type, which, in a sense, belong to the malleable class. These are highly alloyed and are given a short heat-treatment to graphitise part of the carbon and to impart some ductility. Industry can look forward to increased use of such irons not only to supplement the usual and pearlitic malleables, but also to develop new fields for the use of castings.

DEVELOPMENTS IN NON-FERROUS CASTINGS

From an alloy standpoint, the development of various types of silicon bronzes has been of major importance in the past few years. Several of them have made considerable progress in the last year in the engineering field, notably those of the Everdur type and P.M.G. metal. The latter also contains, besides 1.2 to 3.2 per cent. silicon, 0.5 to 1.2 per cent. iron. Some silicon bronzes have been modified in composition to permit heat-treatment.

Silicon has a marked effect on increasing the fluidity of bronzes. While silicon bronzes have had a rather bad reputation with the foundrymen, owing to their tendency towards gas porosity, some of the modified silicon bronzes seem less susceptible to this difficulty. One silicon alloy developed at Battelle is of the latter type. It has 83 per cent. copper, 5 per cent. silicon, 10 per cent. zinc, 1 per cent. manganese and 1 per cent. aluminium, and has a tensile strength of 39.2 to 41 tons per sq. in., a yield of 20.5 to 27.0 tons per sq. in., and an elongation of 1 to 4 per cent.

Hydrogen and Unsoundness

In working with this alloy it was found that the most practical means to eliminate the absorbed hydrogen and make sound castings has been to overheat the melt temporarily, to about 1,090 deg. C., whereby zinc vapour sweeps out most of the gas. After about one minute of this treatment the melt is quickly cooled to the pouring temperature of about 848 deg. C. and cast. This alloy is susceptible to precipitation-hardening. In this treatment it is quenched from 773 to 798 deg. C. and subsequently heated to 300 deg. C., at which temperature it precipitation-hardens very rapidly, giving a maximum hardness in only about 15 min.

Copper-Silicon-Zinc

In studies at Battelle on the question of unsoundness of the copper-silicon-zinc brasses melted in various gases, it was found that hydrogen caused marked unsoundness regardless of the crucible material or the dryness of the hydrogen. While the results on steam were inconclusive, it appeared as if steam had little to do with unsoundness. The author was unable to attribute unsoundness to carbon monoxide. Superheating of this alloy caused the zinc vapours from the alloy to sweep out most of the gas.

Modified Alloys

One of the outstanding alloy developments in copper alloy production has been the use of antimony, arsenic or phosphorus to prevent dezincification in Admiralty and other condenser tube alloys subject to such attack. While the trend in wrought copper production is strongly toward these modified alloys it is doubtful whether the non-ferrous casting industry has as yet utilised antimony, arsenic, or phosphorus to prevent dezincification in copper-zinc castings subject to such attack. The amount of antimony or arsenic used is of the order of 0.1 to 0.2 per cent.

Heat-Treatment

Heat-treatment of non-ferrous alloys is becoming more and more common. The modification of some silicon bronzes and brasses to permit heat-treatment has already been mentioned. Beryllium bronze always depends upon heat-treatment for its best results, and aluminium bronzes, which have been heat-treated for some time, are now being used in heat-treated form to a much larger extent. The copper-chromium alloys now being employed for copper engine heads and for many other purposes are often in the precipitation-hardened state.

Manganese-Base Alloy

In reviewing electrolytic manganese and its alloys, Dean[4] states that alloys containing 65 to 70 per cent. zinc, 20 per cent. manganese and the balance copper, give excellent high-strength castings and should be attractive on account of their cheapness. A manganese-base alloy with 80 to 85 per cent. manganese and 15 to 20 per cent. copper on quenching from a solution temperature has a low hardness of 50 Brinell. In a subsequent precipitation-hardening treatment it reaches a hardness of 500 Brinell.

A very rapid growth has taken place in the production of magnesium castings. Since 1934 the production has increased several times over. The magnesium alloys are also strengthened and made more ductile by heat-treatment, a practice which is commonly resorted to.

Powdered Metal Articles

Powder metallurgy is slowly challenging the casting industry in the production of many articles. Investigations are being conducted in the possibilities of substituting the processes used in powder metallurgy for the production of

(*Continued on page* 182.)

Institute of British Foundrymen

ANNUAL MEETING OF SOUTH AFRICAN BRANCH

In spite of the pressure of work created by war production, no fewer than forty-two members managed to attend the annual general meeting of the South African Branch of the Institute of British Foundrymen, which was held on June 27, following a dinner at the Victoria Hotel, Johannesburg.

The report of the Outgoing Committee was read by Mr. F. C. Williams (hon. secretary) and is appended.

Annual Report

Though the third year of the existence of the Branch has been extremely difficult, the Committee were none the less able to report that the Institute had kept up the high standard set in previous years. A general programme of work for the year was drawn up by the Council in July, 1939, and various committees were elected.

Papers Committee.—Colonel Grose and Mr. Robertson were re-appointed to convene the Papers Committee, with power to co-opt, and these gentlemen carried on through the year. The general meetings proved very successful. The Papers were of a high standard considering that the Branch is still very young, and evoked considerable interest in discussions. Emphasis was laid in the report on the necessity for developing this aspect of the Branch activities.

A short-Paper competition was to have been held in March, but owing to the poor response had to be abandoned.

Technical and Education Committee.—Dr. H. J. van Eck and Mr. Tonge were re-elected to the Committee with power to co-opt, Mr. Petersen being co-opted at a later date. During the course of the year a suggestion was put forward that diplomas should be awarded to the two students in patternmaking and moulding who gained the highest marks in the Union at the end of each year. This matter has been taken up with the Educational Department, Pretoria, and since there seem to be two examinations jointly for patternmakers and moulders, the matter is still receiving attention.

Suggestions put forward by this Committee during an interview with Prof. Orr on the syllabus of technical training of apprentices were readily accepted in regard to patternmakers. Discussions took place subsequently in regard to moulders.

A diploma was offered for the most outstanding piece of work performed in the industry, but owing to the prevailing war conditions no award was made.

A Brochure Committee was appointed consisting of Mr. Robertson and Mr. Petersen, and arrangements are proceeding to have a brochure published containing all the best Papers delivered during the past year, together with any other information which might be useful to members. The "Engineer and Foundryman" is still giving the Institute valuable help by publishing all Papers and discussions.

Membership.—Membership has shown an increase and is now 101. The qualifications for membership and associate membership were to have been tightened up, but owing to the present situation the new regulations will not come into operation for the present.

International Congress.—At the International Congress held in London in June last year, the Branch presented a Paper on "Industrial Legislation in South Africa." A diploma was awarded the Branch in the following terms:—"Awarded to the South African Branch of the Institute in recognition of the excellence of a Paper on the subject of 'Industrial Legislation in South Africa,' read before the International Foundry Congress, London, 1939, and presented by the President, Mr. A. H. Guy."

Election of Office-Bearers

Dr. H. J. van Eck (retiring President) proposed Mr. Walter J. Petersen as President and Mr. J. Tonge as Vice-President. The proposal was seconded by Mr. Holdsworth, and carried unanimously.

In addition to Mr. Petersen and Mr. Tonge, the following nominations for membership of the Council were received: Mr. Holdsworth, Mr. Lion-Cachet, Dr. van Eck, Dr. Marais, Mr. Cartwright, Mr. Ward and Mr. Bragg.

MR. HOLDSWORTH proposed that some kind of tribute should be given to Past-Presidents for the time these gentlemen had given to the Branch. He felt it was only fitting that outgoing Presidents should automatically be elected to the Council for as long as they wished to serve. This proposal was seconded by Mr. Allman, and carried.

DR. VAN ECK expressed his very great pleasure in inducting Mr. Petersen as President. He felt that they could find no better President for the coming year.

MR. PETERSEN, in reply, said that he was deeply gratified by the honour done him, and would strive to be worthy of it.

MR. T. NIMMO DEWAR (Past-President) paid tribute to the work Dr. van Eck had done during the past year as President of the Branch. Dr. van Eck had a long and honourable record in the steel industry, both in South Africa and overseas.

The members were meeting under circumstances which had given many of them a great deal of thought during the past few years, said Mr. Nimmo Dewar, and he stressed the magnitude of the task to be performed by industry in the struggle. He drew particular attention to the part played by the steel industry, both overseas and in South Africa, in enabling people to live in a state of freedom. Innumerable committees were working steadily to speed up production.

Mr. Nimmo Dewar went on to quote from President Lincoln's immortal words at Gettysburg. Those words, he said, came to them after a lapse of about seventy-five years, and were still a doctrine worth fighting for. "We feel that we shall not perish from the earth; that is the spirit in which the Institute is doing its duty," he declared.

Dr. van Eck had taken a prominent part in the Agricultural and Industrial Requirements Commission, mobilising services and investigating the possibilities of local industry, and he had now been appointed chairman of the Commission in succession to the late lamented Mr. Charles Boyd Varty. There could have been no better choice, because Dr. van Eck's motto was "thorough."

In proposing a vote of thanks to Dr. van Eck, Mr. Nimmo Dewar coupled what the retiring President had done for the Institute with what he had done for the country. He thanked him for all that he had done, and was sure that the new President would follow in his footsteps.

Dr. van Eck's Address

DR. VAN ECK, after thanking the members for the support they had given him during the year, and, in particular, for the support accorded at monthly meetings, expressed his gratitude to the Council for their support at committee meetings. He referred also to Mr. F. C. Williams, to whom the Institute was greatly indebted for facilities for publishing proceedings in the "Engineer and Foundryman," a privilege which was of great value to the society. Mr. Williams was largely responsible, and deserved full credit, for the Paper for which the Institute received an award. He hoped Mr. Williams would continue to take an interest in the Institute.

During the whole year, under the threat of war, there had been a great deal of co-operation among foundrymen to meet the requirements of the country. But for the Branch the task would have been impossible, and the Branch's response had been magnificent. They might have been slow in getting started, but had gone on from strength to strength.

The Example of Canada

Dr. van Eck referred to what another Dominion—Canada—had done during the last war. The comparison was particularly apt, because the present position of the South African iron and steel industries was not far behind that of Canada in 1914. Canadian steel production rose during the last war from 800,000 tons per annum to 2½ million tons. Asked how quickly 200,000 empty shells could be produced, industrialists estimated that with the available equipment, eleven years would be required. Yet by the end of the war Canada had produced 75 million shells, filled, fused and ready for the guns. At the outbreak of war there was only one press in the country available for shell production, and this was much too large for the duty required. Within four weeks, however, four presses were built, one of which was actually in operation in three weeks. An electric steel plant was started early in 1917 for the production of shell-steel ingots from 350,000 tons of turnings of no value. Within 4½ months of turning the first sod the first of ten electric steel furnaces was in production. The number of heats obtained daily from each 7½-ton furnace was five or six, a particularly remarkable performance, considering that 98 per cent. of the charge consisted of steel turnings.

"We can do very much more in South Africa than we are doing now," said Dr. van Eck. "Our task is much greater than merely to keep the gold mines going—it is also to assist in the defence of our country. I know that every one is doing his very best."

In the Institute, foundrymen had a means of exchanging views, and he considered that a definite stimulus was provided by the discussion of ideas and methods. One of the present difficulties was that many foundrymen felt they were not doing sufficient in their particular sphere. That was a mistake. Generally speaking, foundrymen were very hard-worked people. He felt they could serve their country best today by producing goods, and this they were doing.

Need for Free Discussion

In regard to meetings, Dr. van Eck pointed out that the vitality of the Branch depended very largely on free discussion. In the case of one outstanding meeting, it was not known till three days before the meeting what Paper would be read. Finally, Mr. Holdsworth came forward with an impromptu Paper, and the meeting proved one of the best the Branch had held. He appealed to members not to come to meetings in the spirit of passengers in a bus, prepared to sit down and be carried along. They should take an active part and be able to feel that they had done something worth while. He made special reference to a Paper read by Mr. Mackay at a recent meeting, which gave a practical insight into foundrymen's problems. He hoped that Papers of a similar nature would be encouraged by Mr. Petersen.

The speaker then referred to Prof. Walker's Paper on the engineering industry on the Rand, and mentioned that the President of the Institute had been asked to support a vote of thanks to the author. It was gratifying to see the interest Prof. Walker had taken in some of the Branch's discussions on technical training. This was a striking indication of the extent to which the work of the Branch was spread by other people, thus reaching a wider public. Prof. Walker thought that students should spend two years on practical work before going to the University. The number of students who completed only the first year of their course seemed at present altogether too high. He felt that a system based on a foundation of practical training was the ideal. There was, instead, a tendency to become intellectualised, which he often thought might be responsible for certain aspects of policy becoming too far removed from the fundamentals of action. Organisers did not get the same satisfaction of setting wheels in motion as the man who actually turned them.

Reverting to Canada's achievements in the last war, Dr. van Eck recalled that a Shell Committee had been established to co-ordinate the work. In the first place, all material had to be local (as is the case in South Africa to-day). Plant and equipment were examined by the authorities before contracts for shell parts were placed. Orders were placed for component parts instead of for complete shells, and the component parts were very carefully inspected before shipping, faulty parts being rejected at the makers' works. There were actually two types of firms engaged in production, some firms supplying components and others building the components into shells and taking the responsibility for the finished articles. The same price was paid to all concerns manufacturing the same article, thus setting a premium on efficiency. The inspection staff of the Canadian munition authorities was 1,500 men with about 80,000 employees. The cost of inspection amounted to 2½ per cent. of the total cost. These figures showed the importance of careful inspection.

Opportunity for Expansion

Apart from the question of national defence, continued Dr. van Eck, they now had an opportunity of placing the heavy engineering industry on a sound footing. The development of the steel and engineering industries, which required no artificial aid, would enable additional employment to be provided and so help to alleviate the consequences of the drift from country to town. It was difficult to prevent this drift, but an attempt could be made to create avenues of employment. The iron and steel and subsidiary industries were the most valuable industries which could be adopted.

Dr. van Eck expressed the opinion that the rigid examination to which products were now subjected was all to the good in assisting to improve quality. He felt that members would agree that to-day the engineering products of the Reef were equal to any in the world. Increased quality and accuracy would be necessary to assist in meeting the post-war flood of competition from millions of people in Europe who would be working for low wages. Some form of protection against this competition might be required temporarily. At the end of the last war they in South Africa were not sufficiently organised and prepared to be able to maintain the enormously increased output of their industries, and valuable ground was lost due to lack of adequate protection when it was most required. Production costs were strongly influenced by industrial legislation, and he felt that some State assistance might legitimately be expected in order to tide the industry over the difficult period of post-war adjustment.

Dealing with the question of substitutes, Dr. van Eck said that many auxiliary materials required in foundries were still imported, and local substitutes would have to be found. To a large extent this was already being done. In this connection there was a field for closer co-operation between the industries and the Universities and other research bodies.

Control Desirable

Dr. van Eck expressed himself as highly optimistic as to the future. However, he considered that expansion in the iron and steel industries should take place according to a fixed plan which embraced the availability of raw materials and markets. Such control should not be on the lines adopted in totalitarian countries, and the individual should be allowed to retain his initiative. On the other hand, excessive internal competition, though it was a very important price-regulating factor, could be as disastrous to development as foreign dumping. Industry must have profit, which is the substance from which it derives its vitality, and conscious control without impairing individualism was the ideal. In the war effort rationalisation was being carried out as far as possible. After the war this policy might have to be continued, in order to get maximum efficiency and output in certain articles.

"Foundries cannot sit still," said Dr. van Eck, and to emphasise this point he quoted the following article on "Powder Metallurgy," by J. C. Chatfield, which appeared in "Refining Technology":—

Powder Metallurgy

Another great contribution to the oil industry appears to have been made by metallurgists. Or, perhaps, you may not consider it an unmixed blessing since it probably will have the effect of reducing the consumption of lubricating oil.

This new contribution lies in a direction somewhat different from that which the metallurgists have taken in helping refiners in the past. It lies in new bearing metals rather than in the development of a new alloy to withstand the punishing temperatures and pressures which the cracking plant designer demands.

The new bearings to which we refer are not new alloys. The newness lies rather in unusual structural effects which have been attained in the process of manufacture known as "powder metallurgy."

Outside of the field of metal technology few have even heard of "powder metallurgy," yet it appears to be an industry which will impress itself on our economic life just as the booming new plastics industry is affecting thousands of manufacturers of all sorts of goods from tail lights to high heels.

In bare outline powder metallurgy consists, first, of the production of finely powdered metals by low-temperature reduction of metal oxides or by mechanical means and, secondly, the pressing and consolidation of these powders into solids. without melting and casting the metal as in normal foundry practice. One of the most useful features of powder metallurgy is that finely-ground particles of metal will weld together or sinter at temperatures perhaps only three-quarters as high as the melting point of the metal.

From the standpoint of the oil industry the most important fact about powder metallurgy is that objects formed of metal powders may have very unusual internal structure. They may be made quite porous, for example. It is this feature which has resulted in the development of pre-lubricated bearings. The motor-vehicle industry is using a growing number of parts made by sintering powdered metals. Recently it was predicted that by 1942 the average motor car will contain 100 lbs. of metal parts pressed from powder, largely replacing castings.

With porous bearings water-pump troubles of an earlier day are on the way out. The capillarity of this type of bearing conveys oil directly through the wall to the bearing surface and ensures an adequate supply of lubricant for all friction surfaces. Oil may be supplied continuously to the outer surface of the bearing from a reservoir and the lubricant manufacturer need not worry about producing a water-pump grease which will stand up under difficult operating conditions.

The pre-lubricated bearing is a boon to the textile manufacturerer whose goods may be ruined by excess oil. Tests have shown that a pre-lubricated bearing sealed in a household appliance will adequately lubricate the machine for several million revolutions. The housewife need no longer wonder whether she oiled the sewing machine or vacuum cleaner last week or last summer.

In many types of equipment the porous, pre-oiled bearing reduces wear. This is true because the pre-oiled bearing provides enough lubricant to minimise wear in the starting period before an oil pump can begin to function. Early pre-lubricated bearings were formed of powdered copper, tin and graphite. Recently iron and iron-copper bearings have been employed because they can be used in more severe service.

In making a powdered-iron article, first the powdered iron is pressed to desired shape in a briquetting machine which may operate at pressures up to 100 tons per sq. in. The powdered-iron briquettes come from the machine looking very much like the finished part but without structural strength.

Briquettes are heat-treated or sintered in an electric furnace at 1,010 to 1,150 deg. C. in an inert atmosphere. Combination of the heat and pressure causes welding of the minute iron particles to create a strong metal object similar in appearance, tensile strength and hardness to a casting. Compressive strength may range from 33.5 to 55.8 tons per sq. in.

Small gears are being produced which are lighter than cast gears due to their porosity but with comparable strength characteristics. From the standpoint of the manufacturer these gears are desirable because they eliminate costly machining and cut metal loss. It is said that the same weight of metal used for a cast gear will produce 3¼ gears by powder metallurgy.

The new industry seems to be hungry for men with a background of technical training. A start has been made in satisfying the demand. Last December, Stevens Institute of Technology began installation of a powder metallurgy laboratory. In February of this year it established a new department devoted to the subject. After only two months the new department has the largest enrolment of any division of the Stevens graduate school.

Foundrymen had to consider competition from developments such as these, commented Dr van Eck, in order to remain on top all the time. In looking for new developments, however, it was important not to forget the old. A young man once expressed surprise that his father with his limited knowledge had obtained the position he had reached. Ten years later, however, he said that it was quite remarkable how much the old man had learned during the past ten years.

In conclusion, Dr. van Eck wished the Branch and the President every success during the coming year.

Vote of Thanks

MR. PETERSEN thanked Dr. van Eck for his address. He proposed Mr. Williams for secretary. This was seconded and carried unanimously. Mr. Aldridge consented to continue as technical secretary.

This concluded the agenda. The meeting then had the pleasure of listening to songs by talented performers, with the vice-president, Mr. Tonge, at the piano.

Physical Specification Chart for Meehanite Metal

The International Meehanite Metal Company, Limited, of 66, Victoria Street, London, S.W.1, have prepared an ingenious specification wheel which details every normally required physical property of six types of engineering irons and on the reverse side five varieties of heat and corrosion resisting alloys. Data (new to us) are given under the general heading of properties under heat influence. These lists show the strength of the alloys at elevated temperatures, the surface loss in inches per year at high temperatures and the yearly growth. Wear-resisting castings being not so well suited for including in the wheel system, the properties of five types are set out across the reverse disc. The wheel, which is good propaganda for the ironfounding industry as a whole, is available to our readers on writing to Victoria Street.

Accelerated Spray Test for Determining the Relative Atmospheric Corrodibility of Ferrous Materials*

By T. SWINDEN, D.Met., and W. W. STEVENSON, A.I.C.

The desirability of having a reliable laboratory method for the rapid evaluation of the relative atmospheric corrodibility of irons and low-alloy steels of the constructional type has long been considered by many workers in the field of corrosion research. The position in regard to relative corrodibility under conditions of immersion has been clarified by the excellent work by Bengough and Wormwell.[1] It is generally accepted, however, that immersion tests do not produce the same order of merit as is obtained in long-period exposure to the atmosphere.

The conditions of atmospheric corrosion entail the wetting of steel by weakly acid liquids (particularly in industrial atmospheres) and subsequent evaporation of the liquids; condensation of liquids and evaporation, with changes of temperature; partial removal by mechanical means of the corrosion product, and so on. The obvious experimental procedure is suggested, therefore, of attempting to reproduce in the laboratory a cycle of atmospheric changes involving wetting and drying, heating and cooling, in which the corrosion is of the oxygen-absorption type. From the wide differences in results obtained by atmospheric exposure and by immersion in acid, the authors consider that hydrogen evolution plays no major part in atmospheric corrosion. Since the supply of oxygen will be facilitated if the corrosive medium is in the form of fine droplets, it is desirable to wet the specimens with a fine spray. Also, as the size of the droplets decreases, it should be possible to increase the acidity of the solution without unduly introducing the effect of hydrogen evolution. This is in line with the views of Evans.[2]

Earlier work on spray tests had been carried out by Evans and Britton,[3] Hatfield and Shirley,[4 5] Hudson,[6] and Schroeder.[7] Using a simple spraying procedure, twice a day for 23 days, Evans and Britton concluded that it seemed possible to obtain, in laboratory spray tests, an order of merit which was a reliable indicator of the "liability to *commence* rusting" under typical service conditions. They suggested $N/100$ sulphuric acid as the spray liquid for urban atmospheres and either sea water or 3.5 per cent. sodium chloride solution for marine atmospheres. They also stated the view that the order of merit for long-time atmospheric exposure was unlikely to be the same as that obtained in short-time laboratory spray tests, at the same time indicating the possibility that more intensive spraying with acid, of the order of 10 times daily with intervening drying periods, might within a reasonable time reveal the long-period order.

Hatfield and Shirley[4] sprayed their specimens at constant spray pressure, once daily for 36 days, using two different types of spray liquid, (*a*) 3 per cent. sodium chloride solution and (*b*) $N/100$ sulphuric acid. Their results showed that some materials in the salt-spray tests corresponded quite well with the short-time field tests, whilst other materials were not so good; the agreement of the acid tests with the short-time field tests was less satisfactory than that for the salt-spray tests. Hatfield and Shirley[5] supplemented their work with one-year field tests. They found good agreement between the salt-spray and the short-time (36-day) field tests for the more resistant steels, but the less resistant steels (of the type dealt with in the present Paper) gave different results. For these steels better correspondence was found between the salt-spray and the long-time (one-year) field tests, but anomalies existed. For instance, the salt-spray tests failed to bring out the beneficial effect of 0.45 per cent. of copper in mild steel. The acid-spray tests did show this, but, on the other hand, the general correspondence between the acid-spray and the field tests was still less satisfactory.

Hudson used a fixed spray device and sprayed his specimens twice daily with $N/100$ sulphuric acid for 20 days. The correlation between Hudson's spray tests and short-time field tests supported the view of Evans and Britton that the intermittent spray test gives the short-period order of merit of the materials tested. Hudson also commented on the fact that better agreement between the two types of test was obtained in the case of ground specimens than of pickled ones, suggesting that this was possibly due to the behaviour of the copper in the copper-bearing steels during pickling.

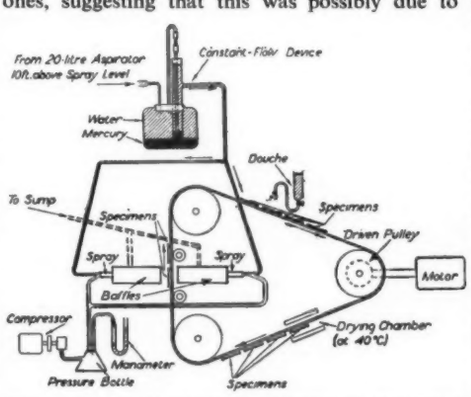


FIG. 1.—DIAGRAM SHOWING PRINCIPLES OF NEW SPRAY APPARATUS.

Schroeder's[7] work is of especial interest, as he rendered the spraying automatic, by mounting the specimens on a belt, driven by motor and reduction gearing, thereby bringing the specimens, at fixed intervals, into the operation zone of the sprays. The first spray apparatus constructed at Stocksbridge actually contained a few of the parts of Schroeder's equipment. Schroeder used sprays consisting of (*a*) $N/100$ sulphuric acid and (*b*) a mixed-salt solution containing 16 g. of ammonium sulphate and 4 g. of ammonium chloride per litre, and he also describes one test in which, in addition to spraying, downpour and sunshine were simulated, by douching the specimens periodically with water, followed by exposure to a heating element. In this test he obtained accelerated corrosion, as compared with tests when spraying only was carried out, and also a marked improvement in correlation with the short-period field test.

A further effort to correlate spray tests with field tests was made by Hatfield and Shirley, Swinden and Stevenson, and Hudson and Banfield,[8] who carried out spray tests at Sheffield, Stocksbridge and Birmingham, and exposure tests at Sheffield and Stocksbridge, on 8 low-alloy structural steels in connection with Part III of the Corrosion Committee's experimental programme. Two types of spray liquid were used, $N/100$ sulphuric acid and the mixed-salt solution previously used by Schroeder (*vide supra*). Comparing the spray-test results with short-period (4-week) and long-period (one-year) field tests, no correlation was found between the results of the intermittent spray tests with the mixed-salt solution and either series of field tests; the spray tests with $N/100$ sulphuric acid were only slightly more satisfactory. Excellent agreement was found in the different series of long-period field tests, but there was no satisfactory correlation between the different laboratories, either in the spray tests or in the short-period field tests. The results of the short-period field tests agreed better with the long-period field tests than did the results of either series of spray tests. In this investigation the spray method in each of the three laboratories was of the static type previously investigated by Hatfield and Shirley[4 5] and by Hudson.[6]

As stated in the Fifth Report of the Corrosion Committee,[9] the authors proceeded to modify and extend Schroeder's automatic spraying apparatus, so that larger specimens, 4 in. by 2 in., could be accommodated. All operations were standardised as far as possible, in an effort to ensure equal treatment for all specimens. The principles observed were those of Schroeder's douching test in that the cycle of operations consisted of intermittent spraying, followed by exposure to a heating chamber; also, the specimens were given a daily douching with water, under standardised conditions, for the purpose of detaching loose rust from the surface.

After detailing the composition of the test materials, the authors give a detailed illustrated description of the original apparatus and the subsequent modifications. One of the difficulties was to maintain a constant spray volume of equal intensity on the two faces of the specimens. This was due to the level of liquid in the spray bottles falling at slightly different rates during a day's run. The apparatus was therefore modified as follows: Instead of using bottles of spray liquid and adjusting the spray pressure periodically, a large aspirator full of liquid is placed 10 ft. above the level of the spray apparatus. The spray liquid is passed from the aspirator through a device which ensures a constant flow of liquid, independent of either the hydrostatic pressure or the back pressure of the air blast. After passing through this device, the stream of liquid is split into two equal streams, each passing through a length of fine capillary tubing and thence to the spray nozzles. The spray liquid is converted into a fine nebula by the air blast, which is kept constant at a definite pressure.

Two additional duplicate sets of tests on the 14 materials were carried out on the spray apparatus modified as above, using (*a*) $N/20$ sulphuric acid and (*b*) a mixed solution containing equal proportions of $N/50$ sulphuric acid and $N/50$ sodium chloride, *i.e.*, centinormal in respect to each constituent. Spraying was carried out for 20 days, 60 cycles per day. The two sets of spray tests using the mixed solution were controlled at different spray intensities, and this is reflected in the loss-of-weight figures. It is seen that the volume of spray liquid falling on the surface of the specimens does not affect materially the order of merit obtained. It should be noted, however, that in all cases the volume of spray was so controlled that the droplets impinging on the specimens did not completely wet the surfaces. Duplicate field tests were also carried out for one year in the semi-industrial atmosphere at Stocksbridge (7 of the materials had been the sub-

* Extracted from a Paper prepared for presentation to the Iron and Steel Institute by the Central Research Department of the United Steel Companies, Limited.

ject of previous one-year field tests at Stocksbridge[1]).

As a result of the good agreement between the long-period field tests and the sulphuric-acid/sodium-chloride spray tests, it was decided to build an entirely new equipment, incorporating additional improvements, in that a direct drive through the gearbox is used instead of a belt drive, and the apparatus has greater stability, achieved by lowering the travelling belt and using metal and Sindanyo parts, instead of wood. Also, the carbon-filament heater lamps were replaced by a strip heater covered by a sheet of stainless steel. This was necessary to accommodate the drying section of the apparatus in the new layout and had the added advantage that the thermometer was not directly exposed to radiation from the carbon-filament lamps. Fig. 1 shows the entire equipment diagrammatically. The results obtained for duplicate tests on 13 materials, using the new equipment, are given in Table I. Observations of the progress of the corrosion were made, but have not been included, as they bore such great similarity to the observations recorded in the Appendix in connection with the earlier spray tests using the mixed sulphuric-acid/sodium-chloride solution. For the tests reported in Table I, the spray volume was controlled to give the maximum wetting of the specimens consistent with maintaining the individuality of the droplets on the surface of the specimens. For the purpose of judging droplet size, a stainless-steel control specimen was incorporated in each series of tests. Since this specimen does not corrode, it is possible to judge the spray volume with greater accuracy, as compared with the spraying of a surface coated with hydrated oxide.

TABLE I.—*Results of the Third Series of Tests using the New Spray Equipment and Spraying with a Solution of N/100 Sulphuric Acid, N/100 Sodium Chloride.*

Spraying carried out for 20 days, 60 cycles per day.

Material.	Mean loss of weight per standard specimen.* G.		Loss in weight referred to steel *X2* as 100.		
	First test.	Second test.	First test.	Second test.	Mean.
Swedish Lancashire iron	2.40	2.51	170	141	155.5
Staffordshire wrought iron	1.53	1.82	109	102	105.5
Aston-Byers iron	1.92	2.42	136	136	136
Ingot iron	1.74	2.51	123	141	132
Rail steel	1.38	1.74	98	98	98
XK (0.2% C, solid)	1.43	1.84	101	103	102
ZK (0.2% C, 0.5% Cu, solid)	1.32	1.66	94	93	93.5
K (1% Cr)	1.35	1.67	96	94	95
L (0.6% Cr, 0.5% Cu)	1.20	1.53	85	86	95.5
N (1% Cr, 0.5% Cu)	1.18	1.42	84	80	82
O (0.5% Cu, 1.5% Mn)	1.29	1.74	91	98	94.5
X2 (0.2% C, balanced)	1.41	1.78	100	100	100
Z (0.2% C, 0.5% Cu, balanced)	1.25	1.61	89	90	89.5

* Total area of standard specimen, 16 sq. in.

TABLE II.—*Orders of Merit for 14 Steels and Irons in Field Tests and Three Types of Spray Tests at Stocksbridge.*

Material.	Field tests. 27/7/37 to 27/7/38.	Spray tests.			
		N/100 sulphuric acid, *N*/100 sodium chloride.		*N*/100 sulphuric acid.	*N*/20 sulphuric acid.
		Old equipment.	New equipment.		
Carbonyl iron	13	13	..*	1	10
Swedish Lancashire iron	14	14	13	13	13
Staffordshire wrought iron	9	8	10	12	7
Aston-Byers iron	12	12	12	14	14
Ingot iron	11	11	11	11	11
Rail steel	8	7	7	10	12
XK (0.2% C, solid)	7	9	9	8	8
ZK (0.2% C, 0.5% Cu, solid)	3	3	4	6	4
K (1% Cr)	6	6	6	6	5
L (0.6% Cr, 0.5% Cu)	2	2	2	3	2
N (1% Cr, 0.5% Cu)	1	1	1	1	1
O (0.5% Cu, 1.5% Mn)	4	4	5	5	2
X2 (0.2% C, balanced)	10	10	8	9	9
Z (0.2% C, 0.5% Cu, balanced)	5	5	3	4	6

* Carbonyl iron was not tested in this series.

TABLE III.—*Orders of Merit for 7 Steels in Two Series of Field Tests and Three Types of Spray Tests at Stocksbridge.*

Material.	Field tests.		Spray tests.			
	A. 12/6/35 to 11/6/36.	*B.* 27/7/37 to 27/7/38.	*N*/100 sulphuric acid, *N*/100 sodium chloride.		*N*/100 sulphuric acid.	*N*/20 sulphuric acid.
			Old equipment.	New equipment.		
XK (0.2% C, solid)	6	6	6	7	6	6
ZK (0.2% C, 0.5% Cu, solid)	3	3	3	3	4	4
K (1% Cr)	5	5	5	5	4	5
L (0.6% Cr, 0.5% Cu)	2	2	2	2	2	2
N (1% Cr, 0.5% Cu)	1	1	1	1	1	1
O (0.5% Cu, 1.5% Mn)	3	4	4	4	5	2
X2 (0.2% C, balanced)	7	7	7	6	7	7

The orders of merit for the 14 materials in the field tests and the three types of spray tests are given in Table II, whilst Table III shows the orders of merit for 7 steels which have been the subject of two long-period field tests at Stocksbridge and three types of spray test.

Consideration of the Results

In the first set of spray tests, using *N*/100 sulphuric acid, the orders of merit for certain materials were in reasonably good agreement with the field-test results, but the "spread" of the results was of a very low order. In fact, of 28 tests carried out on 14 materials, the highest and lowest loss-of-weight results (referred to the standard steel *X2* as 100) were 116 and 86, respectively, the 86 result being an isolated figure, the next lowest being 91. For the second series of spray tests, therefore, an attempt was made to increase the relative corrosion of the materials. Two methods were adopted, *viz.* (*a*) increasing the acidity and (*b*) introducing a second acid radical in the form of a salt addition.

The results showed that method (*a*) had no appreciable effect on the "spread" of the results; the increased acidity of the solution caused acid attack, with sulphate formation and deposition on the specimens, and, apart from the relatively poor order of merit revealed, could not be regarded as an improvement on the *N*/100 sulphuric acid solution used for the first series of tests. On the other hand, the mixed sulphuric-acid/sodium-chloride solution increased the "spread" of the results materially—the maximum and minimum of the first set being 162 and 81, respectively—at the same time giving orders of merit very close to those of the one-year field tests. The actual loss-of-weight figures for the first set, however, were considered to be on the low side, with the result that a definite increase was made in the volume of spray used, and a decrease in droplet size, for the duplicate tests with the mixed liquid. The corrosion rate was thus increased by two to three times that of the first set and a fairly wide "spread" was also obtained—maximum 156.5, minimum 82. The agreement of the second set with one-year field tests, with respect to orders of merit, was quite good, as in the first set. It should be noted in the tables that the mean of the loss-of-weight figures (referred to steel *X2* as 100) has been taken to obtain the reported orders of merit for all the tests.

The tests carried out on the new equipment were virtually made under the same experimental conditions as those used for the second set of sulphuric-acid/sodium-chloride spray tests. The results of the new-equipment tests are given in Table I, and similar observations may be made in regard to them. The actual loss of weight is reasonably high—from 1.18 to 2.51 g. on 125-g. specimens—the "spread" of the results is quite good and the orders of merit for 13 materials are reasonably close to those obtained in one year's atmospheric exposure.

Conclusion

In the view of the authors, the accelerated spray test described is of sufficient promise to be regarded as the basis of a laboratory method for the determination of the relative corrodibility of irons and constructional steels. In order to obtain reliable results by this method, certain experimental conditions should be adhered to, as postulated below:

(1) Visible acid attack should not occur. Acid attack was obtained with *N*/20 sulphuric acid but not with *N*/100 acid under the conditions prevailing in the authors' experiments. Hence the maximum permissible acid concentration is at some stage between these two limits.

(*Continued on page* 178.)

Manganese Losses in Open-Hearth Practice

SUBSTANTIAL RECOVERY AFTER MELTING

The function of manganese in steelmaking in the open-hearth furnace, and particularly the losses sustained and means for their reduction, is again discussed on the basis of further experimental work by P. BARDENHEUER and G. HENKE in Report No. 366 of the steelworks committee of the Verein deutscher Eisenhüttenleute, published in a recent issue of "Stahl und Eisen." In open-hearth charges, the manganese is partially oxidised and passes into the slag; its distribution between charge and slag is in a definite ratio, which is determined by the temperature and the composition of the slag. If the total manganese present is high, the charge will contain a high content of manganese and the slag a high proportion of manganese oxide. Unlike ferrous oxide, manganese oxide is insoluble in the slag, but its amount reduces the content of ferrous oxide in the slag and hence the oxygen supplied to the charge. It is apparent, therefore, that an increase in the concentration of manganese will result in a decreased concentration of oxygen in the charge.

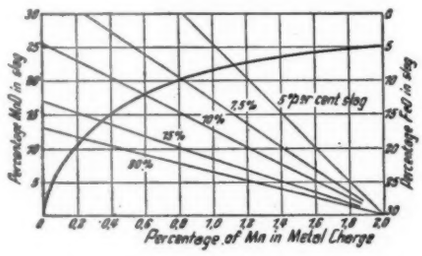


FIG. 1.—EFFECT OF SLAG YIELD ON RECOVERY OF MANGANESE WITH 2 PER CENT. MN IN SYSTEM. (AFTER W. OELSEN.)

In open-hearth practice, these considerations have led to a high concentration of manganese being introduced to the charge at the outset, in order to have an initial low concentration of oxygen. But P. Bardenheuer and G. Thanheiser have stressed that manganese commences to play an important part in the reaction only towards the end of the decarburisation period, since before this point is reached the carbon content of the charge owing to its high reducing action alone governs the oxygen content of the charge. In addition, at the start after the charge has been melted, *i.e.*, when the temperature is still comparatively low, there must be a sufficient supply of ferrous oxide from the slag to allow the charge to boil vigorously. But if the manganese in the charge is high, a good boil can only be obtained by adding large quantities of ore, which unnecessarily increases the quantity of slag and causes the bulk of the manganese to pass into the slag, without the metal affecting the course of the reaction favourably or improving the quality of the steel. It is only when conditions can be created under which an appreciable amount of the slagged manganese is again reduced, that a higher Mn content in the charge is justified in order to save ferro-manganese. Nevertheless, in many cases, the manganese from the slag cannot be reduced, owing for instance to the narrow limits for phosphorus which are prescribed; as a result, in spite of a higher provision of Mn in the charge a low-Mn and high-O charge remains, to which considerable amounts of ferro-manganese have then to be added before tapping. By this procedure, there can be no question of removing the oxygen from the charge by means of manganese, for in spite of a high consumption of manganese the total oxygen in the final product is usually still very high.

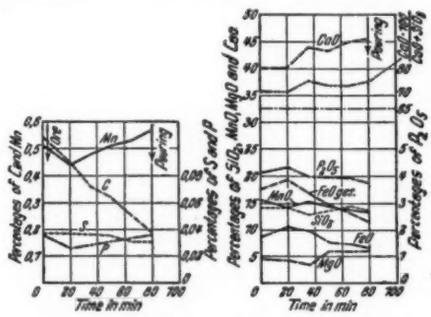


FIG. 2.—VARIATIONS IN COMPOSITION OF CHARGE AND SLAG OF MELT NO. 1.

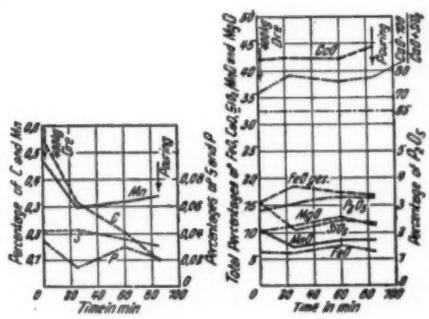


FIG. 3.—VARIATIONS IN COMPOSITION OF CHARGE AND SLAG IN MELT NO. 5.

As in the open-hearth process, so in other steelmaking processes a high consumption of manganese does not necessarily, and as a matter of course, lead to an improvement in the quality of the steel. On the other hand, more exact knowledge of the mechanism of steelmaking operations has led to the development of methods by which the oxygen content of the bath can be kept low by the powerful reducing action of carbon, and at the same time the manganese in the charge can be utilised to such good purpose that the finished steel after proper decarburisation not only contains

TABLE I.—*Experimental Melt No. 4.*

	C %	P %	Mn %	S %	Si %	kg.	%	Si kg.	Si %	Mn kg.	Mn %	P kg.	P %
Stahleisen	3.85	0.079	3.55	0.031	1.03	20,600	18.7	212		731		16.3	
Converter metal	0.02	0.070	0.35	0.039		46,100	41.7			162		32.3	
Scrap	0.39	0.038	0.37	0.032	0.03	43,800	39.35	13		162		16.7	
Ore						270	0.25						
Charge						110,770	100	225	0.203	1,055	0.95	65.3	0.059
Lime						4,300	3.89						
Yield						103,830							
Slag						11,600	11.2						

Analyses

Sample No.	Time after hr.	Steel C %	Steel P %	Steel Mn %	Steel S %	Mn recovery %	Slag Total Fe %	Slag FeO %	Slag Fe_2O_3 %	Slag MnO %	Slag P_2O_5 %	Slag SiO_2 %	Slag CaO %	Slag Al_2O_3 %	Slag MgO %	Slag Total S %	Basicity	Additions
1	4.35	0.55	0.034	0.47	0.042	46.5	12.17	6.42	10.27	10.55	2.81	15.52	42.14	1.54	10.34	0.07	71.4	400 kg. ore
2	5.00	0.32	0.015	0.30	0.043	29.6	14.27	6.18	13.54	7.38	3.04	10.72	42.48	2.99	11.10	0.07	78.4	
3	5.35	0.21	0.030	0.32	0.036	31.2	13.41	7.53	10.81	8.51	3.32	12.10	42.24	2.17	12.98	0.21	76.0	300 kg. FeMn
4	6.00	0.10	0.021	0.34	0.031	33.4	13.12	6.42	11.63	8.59	2.29	11.74	44.54	1.80	11.38	0.23	77.5	(ladle)

Balance

Charge	225 kg. Si = 481 kg. SiO_2	1,055 kg. Mn = 1,360 kg. MnO	65.3 kg. P = 149.6 kg. P_2O_5
Steel	— —	352 kg. Mn	21.8 kg. P
Slag	1361	771 kg. Mn	167.7 kg. P
		1,123 kg. Mn = 1,450 kg. MnO	189.5 kg. P = 434.0 kg. P_2O_5
Difference	+ 880 kg. SiO_2	+68 kg. Mn +90 kg. MnO	+124.2 kg. P + 284.4 kg. P_2O_5

very little oxygen, but also has such a manganese content, even with a relatively low consumption of manganese, that the subsequent addition of ferro-manganese becomes superfluous. The absence of ferro-manganese also eliminates the danger of lowering the quality of the steel through the impurities introduced by the alloying components added.

According to Bardenheuer and Thanheiser, increasing the temperature of the charge and the basicity of a slag, not previously purely basic, results in deoxidation of the bath by carbon and also favourably influences the recovery of manganese from the small quantity of slag formed. The effect of the slag quantity on the recovery of manganese is shown diagrammatically in Fig. 1, due to W. Oelsen, where it is assumed that the manganese in the charge and slag totals 2 per cent., and the total ferrous oxide and manganous oxide in the slag is 30 per cent. With a slag yield of 20 per cent., the bath then contains 0.24 per cent. Mn and the slag 11.5 per cent. MnO; with 10 per cent. slag, the melt contains 0.6 per cent. Mn and the slag 18 per cent. MnO; at 5 per cent. slag, the Mn in the bath may rise to 1.1 per cent. and the MnO content of the slag to 22 per cent. It thus appears possible that, by reducing the slag formed to a minimum, a considerable proportion of the Mn previously thought indispensable can be saved. For a series of open-hearth melts, Bardenheuer and Thanheiser showed that with a small slag yield a relatively

TABLE II.—*Experimental Melt No. 5.*

	C %	P %	Mn %	S %	Si %	kg.	%	Si kg.	Si %	Mn kg.	Mn %	P kg.	P %
Stahleisen	3.8	0.113	3.20	0.036	0.93	22,000	19.9	204		705		24.9	
Converter metal	0.09	0.159	0.42	0.026		42,700	38.7			180		67.8	
Scrap	0.09	0.030	0.38	0.049	0.09	45,300	41.23	41		172		13.6	
Ore						193	0.17						
Ferro-manganese						—	—						
Charge						110,193	100.00	245	0.22	1,057	0.96	106.3	0.096
Lime						1,500	1.36						
Yield						106,210							
Slag						4,030	3.79						

Analyses

Sample No.	Time after hr.	Steel C %	Steel P %	Steel Mn %	Steel S %	Mn recovery %	Slag Total Fe %	Slag FeO %	Slag Fe_2O_3 %	Slag MnO %	Slag P_2O_5 %	Slag SiO_2 %	Slag CaO %	Slag Al_2O_3 %	Slag MgO %	Slag Total S %	Basicity	Additions
1	4.30	0.54	0.035	0.51	0.037	51.1	13.71	8.78	9.85	15.61	4.12	14.20	40.00	1.75	4.40	0.05	71.2	300 kg. ore
2	4.50	0.45	0.026	0.44	0.037	44.1	15.12	10.46	10.01	14.04	4.32	14.20	40.30	1.55	4.10	0.05	71.3	
3	5.05	0.36	0.028	0.48	0.036	48.1	13.11	9.95	7.71	15.38	4.01	13.00	43.99	1.75	3.32	0.13	75.0	
4	5.20	0.32	0.031	0.51	0.035	51.1	11.51	7.75	7.86	14.59	3.98	13.70	43.30	1.71	6.01	0.14	73.8	
5	5.35	0.25	0.034	0.53	0.031	53.1	10.41	7.37	6.73	13.80	3.92	14.60	44.88	1.73	5.87	0.16	73.5	
6	5.50	0.19	0.036	0.57	0.031	57.6	10.01	6.46	7.12	13.42	3.75	13.60	45.59	1.80	5.92	0.16	75.1	

Balance

Charge	245 kg. Si = 524 kg. SiO_2	1,057 kg. Mn = 1,362 kg. MnO	106.3 kg. P = 243.4 kg. P_2O_5
Steel	— —	609 kg. Mn	38.2 kg. P
Slag	457 kg. SiO_2	420 kg. Mn	66.0 kg. P
		1,029 kg. Mn = 1,328 kg. MnO	104.2 kg. P = 238.6 kg. P_2O_5
Difference	+ 23 kg. SiO_2	−28 kg. Mn −34 kg. MnO	−2.1 kg. P −4.8 kg. P_2O_5

TABLE III.—*Experimental Melt No. 6.*

	C %	P %	Mn %	S %	Si %	kg.	%	Si kg.	Si %	Mn kg.	Mn %	P kg.	P %
Stahleisen	4.05	0.111	3.46	0.036	0.96	18,400	16.6	177		636		20.4	
Converter metal	0.13	0.087	0.21	0.046		41,300	37.4			87		36.0	
Scrap	0.06	0.017	0.40	0.036	0.05	46,150	41.5	23		185		7.85	
Castings	3.55	0.083	0.56	0.082	2.44	5,000	4.5	122		28		4.15	
Charge						110,850	100.00	322	0.29	936	0.845	68.40	0.062
Lime						1,500	1.35						
Yield						107,440							
Slag						3,920	3.65						

Analyses

Sample No.	Time after hr.	Steel C %	Steel P %	Steel Mn %	Steel S %	Mn recovery %	Slag Total Fe %	Slag FeO %	Slag Fe_2O_3 %	Slag MnO %	Slag P_2O_5 %	Slag SiO_2 %	Slag CaO %	Slag Al_2O_3 %	Slag MgO %	Slag Total S %	Basicity	Additions
1	4.20	0.46	0.037	0.46	0.049	52.5	10.71	8.53	5.86	15.94	2.42	20.00	37.34	1.96	6.76	0.12	63.4	
2	4.40	0.43	0.041	0.51	0.047	58.4	10.91	8.91	5.71	14.37	2.28	19.50	38.53	1.80	7.05	0.13	64.8	
3	4.55	0.35	0.041	0.56	0.047	64.6	8.41	7.75	3.43	13.76	2.09	21.90	40.57	1.84	6.46	0.14	63.4	
4	5.10	0.30	0.037	0.53	0.047	60.7	9.11	8.27	3.86	13.33	1.95	21.40	40.89	1.93	7.43	0.16	64.3	
5	5.25	0.26	0.044	0.58	0.047	66.5	9.01	6.59	5.57	12.51	1.81	20.90	40.54	1.78	8.69	0.10	64.7	
6	5.40	0.20	0.038	0.53	0.042	60.7	11.31	9.04	6.14	11.89	1.64	17.40	39.34	1.56	12.00	0.09	68.0	
7	6.00	0.16	0.033	0.52	0.044	59.7	10.61	7.59	6.57	12.44	2.02	17.40	39.96	1.64	10.66	0.12	68.5	

Balance

Charge	322 kg. Si = 688 kg. SiO_2	936 kg. Mn = 1,210 kg. MnO	68.4 kg. P= 157 kg. P_2O_5
Steel	— —	558 kg. Mn	35.5 kg. P
Slag	— 682 kg. SiO_2	378 kg. Mn	34.6 kg. P
		936 kg. Mn = 1,210 kg. MnO	70.1 kg. P= 161 kg. P_2O_5
Difference	−6 kg. SiO_2	— —	+ 1.7 kg. P +4 kg. P_2O_5

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low concentration of Mn in the charge is sufficient for producing satisfactory quality steels with requisite Mn content, no further addition of ferro-manganese being required to finish off the melt.

Influence of Melting Procedure

Continuing these investigations, the authors have studied the relationship between melting practice and manganese recovery in basic open-hearth furnaces, using metal previously treated in the basic converter, in order to determine primarily those conditions of operation under which the manganese added to the charge is utilised to the best purpose. The experimental melts were prepared in 100-ton furnaces with a hearth area of 55 sq. m., heated with cold coke-oven gas with a lower calorific value of about 4,150 units; the gas was not carburised. The air was preheated in four checker chambers to between 1,050 and 1,150 deg., and the charge was composed of about 42 per cent. scrap, 19 per cent. molten stahleisen, and 33 per cent. molten metal from the 45-ton basic converter. Estimations were made of the quantity and chemical composition of the charge, the additions, the finished steel, and of the slag. Samples were also taken of the bath and the slag to determine the variations in concentration during the working period. The first four melts examined were prepared

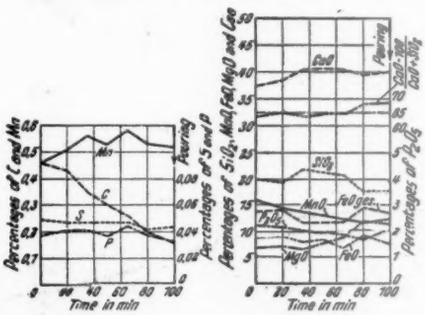
Percentage of C and Mn
Percentages of S and P
Percentages of SiO2, MnO, FeO, MgO and CaO
Percentages of Fe2O3
Time in min
Time in min

FIG. 4.—VARIATIONS IN COMPOSITION OF CHARGE AND SLAG IN MELT NO. 6.

by the standard procedure, and as the results of these were more or less concordant details are given of only one of these melts.

Full data of this melt are given in Table I and Fig. 2. The total weight of the charge was 110.77 tons with a P content of 0.070 per cent. and an Mn content of 0.35 per cent. in the converter metal. This gave a total P value of 0.059 per cent. and a total Mn of 0.95 per cent. in the charge. On adding 3.89 per cent. lime, the slag yield was 11.2 per cent. Elimination of P and S during melting was good; on adding 400 kgs. of ore the Mn dropped from 0.47 per cent. to 0.30 per cent., and subsequently increased to only 0.34 per cent. The Mn recovery factor was thus only 33.4 per cent.

On evaluating the results of these first experiments, it was found that the slag contained a larger proportion of slag-forming components than should result from the reactants in the charge and the additions. These slagging components of unknown origin consisted mainly of phosphoric acid and silica, which must have been brought into the furnace by the molten metal. In the 100-ton melts investigated, the excess of phosphoric acid found was about 600 kgs. and that of silica 900 kgs. These two undesirable slagging components alone required the consumption of 700 and 1,700 kgs. of lime respectively, so that their presence increased the quantity of slag formed in each of the preliminary experiments by between 3 and 4 tons. By inserting a teeming ladle with a lip of 70 mm. dia. between the converter and the open hearth, the whole of the slag in the converter metal could be prevented from reaching the furnace, while the slag of the stahleisen could also be retained without difficulty. Since it must be assumed that the excess silica found came from the green sand lining of the tipping ladle for pouring in the molten charge, the spout was lined with tar dolomite, and these precautions adequately prevented transfer of any slagging components of unknown origin to the furnace and compensated the difference in the materials balance or reduced it to a negligible value.

A number of experiments were made employing these precautions; details of two are given here, these experiments being conducted in a stationary furnace with a low-refining flame. The data for melt No. 5 are collected in Table II and Fig. 3, where the total weight of the charge was 110.19 tons, including 19.9 per cent. stahleisen. The converter metal contained 0.159 per cent. P and 0.42 per cent. Mn, so that the charge contained a total of 0.096 per cent. P and 0.96 per cent. Mn. Decarburisation was effected in the usual way at a rate of 0.26 per cent. C per hr. after adding 300 kgs. of ore. On charging the Mn at 0.51 per cent. was too high, but dropped temporarily to 0.44 per cent. on adding the ore, when it steadily increased again to 0.57 per cent. The recovery of Mn, *i.e.*, the proportion retained in the finished steel, was finally 57.6 per cent. Under the action of the ore, the P content also dropped from 0.035 per cent. to 0.026 per cent., but later again attained its preliminary value of 0.036 per cent. Both dephosphorisation and desulphurisation were satisfactory on adding 1.36 per cent. lime and with a slag amounting to 3.79 per cent.

In experiment 6, of which details are given in Table III and Fig. 4, the weight of the charge was 110.85 tons, consisting of 16.6 per cent. of stahleisen and 4.5 per cent. chill castings; decarburisation at the rate of 0.18 per cent. C per hr. was effected without the addition of ore. Lime added was 1.35 per cent. and the slag produced 3.65 per cent. The converter metal contained 0.087 per cent. P and 0.21 per cent. Mn, *i.e.*, they were roughly standard, so that the charge contained on the whole 0.062 per cent. P and 0.85 per cent. Mn. In spite of the smaller amount of Mn present, the Mn in the charge temporarily rose to 0.58 per cent., again dropping to 0.52 per cent. at the end. The Mn factor was 59.7 per cent.; dephosphorisation and desulphurisation were satisfactory considering the high silica content. By arresting all superfluous slag-forming elements, the lime value could be reduced to nearly a third of the amount hitherto considered as necessary. This offered a simple means for reducing the amount of slag from an average of roughly 10 per cent. to about 4 per cent.

(To be continued.)

(Concluded from next column.)

time to time patches of thick rust were shed. At the end of the test all the specimens were dark brown in colour, the irons being slightly lighter and steels *K*, *L* and *N* being slightly darker than the remainder.

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Accelerated Spray Test for Determining the Relative Atmospheric Corrodibility of Ferrous Materials

(*Continued from page* 174.)

(2) The spray should consist of very fine droplets, each droplet being surrounded by air.

(3) The stainless-steel control specimen should not be *completely* wetted. This is determined experimentally by the size and intensity of the sprays, and the time taken in passing the sprays. This affords a ready means of avoiding excess spray liquid on the specimens, which would reduce the rate of oxygen supply to them.

The results have been placed on record for the main purpose of encouraging other workers in this field, who may consider it worth while to pursue the method with other spray solutions, or may introduce other modifications for the additional improvement of the method. It is well known that the relative corrodibility of ferrous materials differs in different types of atmosphere, and it is thereby feasible that a spray solution which gives the Stocksbridge or Sheffield order of merit may not be suitable for reproducing the order of merit obtained in urban or marine atmospheres. Further research in this direction is necessary.

Acknowledgments

The authors wish to express their thanks to the members of the Laboratory Corrosion Sub-Committee, particularly Dr. U. R. Evans, Dr. G. D. Bengough, F.R.S., and Dr. J. C. Hudson, for helpful encouragement during the progress of the work; to Mr. H. Padget for carrying out the experimental work; and finally to the directors of the United Steel Companies, Limited, for the necessary permission for publication.

APPENDIX

Summary of Observations on the Progress of the Tests

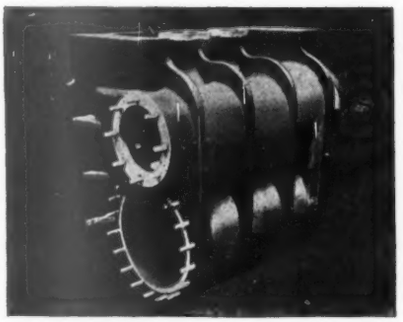
First Series of Spray Tests Sprayed with N/100 *Sulphuric Acid.*—All specimens except carbonyl iron completely rusted to lighter brown in one day. Carbonyl iron completely rusted in four days. During the course of the test the rust on all specimens became progressively darker and thicker. Steel *O* had the darkest-coloured rust and the irons were somewhat lighter and more red than the steel specimens, which were generally dark brown in colour.

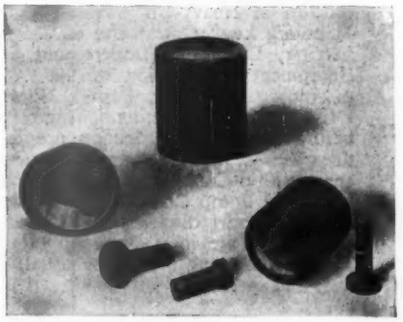
Second Series of Spray Tests Sprayed with N/20 *Sulphuric Acid.*—All specimens completely rusted to dark purplish brown in one day. During the course of the test the rust on all specimens became progressively darker and thicker, finishing much darker in colour than that produced by atmospheric corrosion at Stocksbridge. There was definite evidence of sulphate on the surfaces of all the specimens from an early stage in the tests.

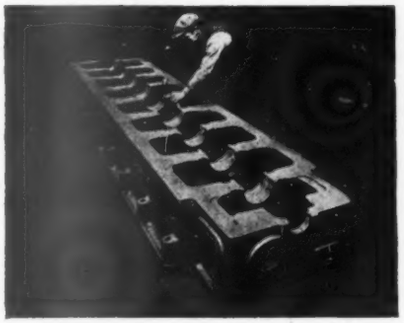
Second Series of Spray Tests Sprayed with N/100 *Sulphuric Acid,* N/100 *Sodium Chloride.*—All specimens except carbonyl iron completely rusted to light brown after two days; carbonyl iron rusted completely in three days. During the course of the test all materials progressively darkened and finished dark brown in colour. The second set of specimens had much coarser rust than the first set owing to the increased spray volume.

Atmospheric Exposure for One Year facing North and South.—All specimens rusted to red-rust colour in one day, owing to the action of dew. During dry periods the rust became lighter in colour, and there was a tendency for the south face to be slightly lighter than the north. During the course of the test the rust became gradually darker in colour, and from

(*Concluded at foot of previous column.*)







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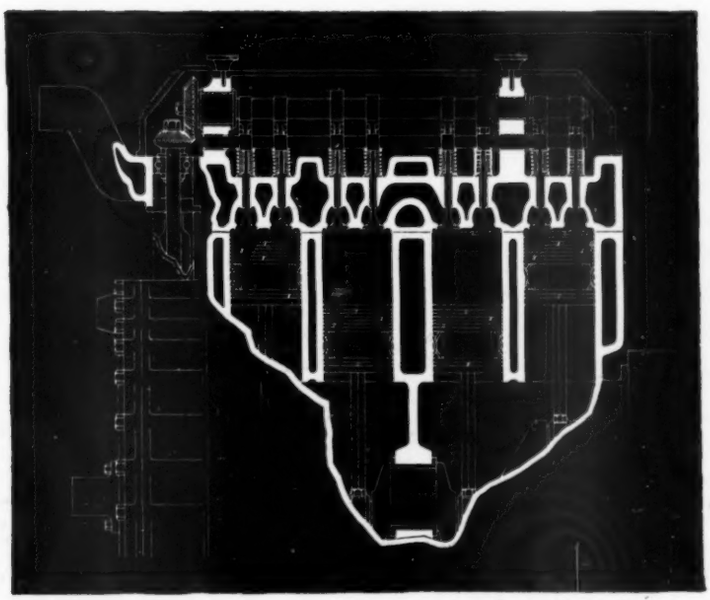

W.59

The Week's News in Brief

Trade Talk

THE NEXT annual meeting of the American Society for Testing Materials will be held in Chicago from June 23 to 27, 1941.

WHEN THE EMPLOYEES of British Insulated Cables, Limited, decided to start a "Spitfire" Fund, the company offered to subscribe an amount equal to the total given by the employees. Within a short while a cheque for £5,000 was sent to the Minister for Aircraft Production.

NEARLY 4,000 TONS of salvage has been disposed of by the Southern Railway during one month, including 3,300 tons of iron and steel, mainly old rails and chairs. Among the old metals handed over for the Government's war use are two 200-ton hydraulic power accumulators.

ARRANGEMENTS ARE BEING MADE, it is understood, to supply steel helmets to certain workers engaged in vital war production, to protect them against fragments of A.A. shell, spent machine-gun bullets, etc. The workers concerned are those employed wholly or mainly out of doors, or under unprotected glass roofs.

IT HAS COME to the notice of the Air Ministry that various organisations are compiling and collating information about the damage caused by air raids on this country. By so doing—perhaps unwittingly—these organisations are contravening a defence regulation. Any person or organisation wishing to compile information of this sort should first consult the appropriate Air Ministry Branch (A.I.1s).

THE SESSION 1940-41 of the Manchester Municipal College of Technology will open on Thursday, September 26, and will end on July 25, 1941. The work of the Faculty of Technology in the University includes:—Advanced study and research in various branches of science and technology; undergraduate courses extending over three years and leading to the degree of B.Sc.Tech. and to University Certificates in mechanical engineering, electrical engineering, applied chemistry, building and mining. Students will be enrolled on September 23, 24 and 25.

THE FOLLOWING INDUSTRIALISTS have been appointed to the Manchester and district panel of the Emergency Services Organisation for obtaining the most rapid repair possible of damage which may be done by the enemy to factories producing essential war supplies:—Chairman, Mr. G. E. Bailey, director and general manager of works, Metropolitan-Vickers Electrical Company, Limited; hon. secretary, Mr. J. Bissett, director, Manchester District Engineering Employers' Association; Mr. H. H. Dobson, managing director of A. V. Roe & Company, Limited; Major T. M. Barlow, managing director, Fairey Aviation Company, Limited; Alderman J. H. Kearns, Electrical Trades Union. The panel has appointed an executive committee with M. T. T. Evans, of Metropolitan-Vickers Company, Limited, Trafford Park, Manchester, as its secretary.

Obituary

MR. JOHN PRITCHARD, of St. Helens, has died at the age of 87. He was principal of John Pritchard & Sons, Limited, ironfounders, of St. Mary's Street, St. Helens.

MR. HENRY JAMES ADAMSON, of Cambridge Road, Ansdell, who has died at the age of 82, was in business with his father in Warrington as ironfounders in his younger days. In 1900 he went to America where he established an ironfoundry in Chicago. He returned to England seven years later and supervised a foundry in Widnes, until his retirement.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Vandyk Machine Tool Company, Limited, 19, North Church Street, Sheffield—Capital, £100. Directors: C. S. Garraway and Kathleen Dodgson.

E. F. Westaway, Limited—Capital, £1,000. Steelmakers, etc. Directors: A. Hattersley, 22, Kingsley Park Avenue, Sheffield; and E. F. Westaway.

Personal

PROF. T. R. LAWSON, well known for his work on the yield point of structural steel, has been elected an honorary member of the American Society for Testing Materials, of which he was President in 1932.

MR. G. R. T. TAYLOR has resigned his seat on the boards of Vickers, Limited, and English Steel Corporation, Limited, in view of his many other interests. He retains his directorship of Taylor Bros. & Company, Limited, a subsidiary of the English Steel Corporation.

MR. JOHN A. MCCULLOCH, who has had long service with R. & W. Hawthorn, Leslie & Company, Limited, shipbuilders and engineers, Hebburn and Newcastle, has resigned from the position of secretary owing to ill-health. His place is to be taken by Mr. R. J. Allan, a director of the company.

MR. A. H. GUY, a Past-President of the South African Branch of the Institute of British Foundrymen, and head of Eclipse Tube Mill Liners (Proprietary), Limited, of Benoni, has been invested by His Excellency the Governor-General, the Right Honourable Sir Patrick Duncan, G.C.M.G., with the badge of office as President of the South African Red Cross Society.

LT.-COL. J. H. M. GREENLY, chairman of Babcock & Wilcox, Limited, Renfrew, who was sent out by the Government to Canada and United States a year ago to set up a purchasing organisation in each country, has completed his task and returned home. The Government have released him from his appointment of Controller-General of the British Supply Board to Canada and United States with a view to his taking up other work.

Wills

BROWN, A. C., retired steelfounder, of Renfrew	£3,591
TUCKER, ALFRED, retired metal merchant, of Cardiff	£11,733
BOOTHBY, T., of Sutton-on-Sea, Lincs, retired steel merchant	£5,804
PICKUP, HARRY, of Scarborough, director of H. Pickup, Limited, engineers and ironfounders	£47,013
THOMAS, H. C., of Swansea, secretary of the International Tinplate Cartel and of the Welsh Plate and Sheet Makers' Association ...	£6,659
ARMITAGE, WILLIAM JAMES, of Hildenborough, Kent, a director of Brown Bayley's Steel Works, Limited, Farnley Iron Company, Limited, and the Hoffmann Manufacturing Company, Limited	£136,585

Company Meeting

Brightside Foundry & Engineering Company, Limited

Effective steps had been taken to maintain their plant and machinery in efficient order, and due to extra wear and tear the normal allowance usually provided for depreciation had been increased, said MR. FREDERICK W. FIRTH (chairman), who presided at the annual meeting of the Brightside Foundry & Engineering Company, Limited, at Sheffield on September 1. The reorganisation schemes were completed, and they had now a well-equipped and up-to-date works. While they had secured a certain number of contracts from abroad, they were now finding it increasingly difficult to secure as much export business as they would like, due in some measure to the limited number of markets available. The company's foundries, engineering shops and heating, pipework and air-conditioning departments covered a wide field of activity, and all had been fully occupied during the year and continued to progress. The year's turnover exceeded £2,000,000, and their direct wages on production showed an increase of 45 per cent. The National Savings campaign had their full support, and advantageous terms had been offered to their employees to encourage them to save in this manner. Concluding with a personal reference, Mr. Firth said that last month he completed 50 years' service with the company.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

522,475. BRISTOL AEROPLANE COMPANY, LIMITED, GADD, E. R., and KEATES, H. Manufacture of nitrided steel articles.

522,561. UDY, M. J. Materials for use in the production of chromium and alloys containing chromium.

522,731. MEYER, L. W. (Naamlooze Vennootschap Philips' Gloeilampenfabrieken). Permanent magnets, and processes of treating alloys for such magnets.

Reports and Dividends

Modern Machine Tools, Limited—Interim dividend of 7½ per cent.

Cammell, Laird & Company, Limited—Dividend of 4 per cent., actual, less tax, on the ordinary shares.

Contract Open

Newcastle-upon-Tyne, September 14—Supply and erection of ventilation and gas filtration plant, ducting and heater, and emergency generator set, for the Town Council. The City Engineer, Town Hall, Newcastle-upon-Tyne.

Publication Received

Transactions of the Manchester Association of Engineers, Session 1939-40. Edited by T. Makemson (secretary) and J. Bolton (assistant secretary). Published by the Association, St. John Street Chambers, Deansgate, Manchester, 3.

A wider range of subjects is included in this year's "Transactions" than is perhaps usual, which enhances rather than detracts from its interest to the general reader. Amongst the subjects dealt with are Fuel Oils and their Combustion in Heavy-Oil Engines; Equipment for Handling Lock Gates; Use of Models in Engineering; Design of Boilers and Boiler-House Equipment; Demolition of the "Mauretania" (a most fascinating Paper); Electric Motor Drives; and Die-Casting. Three Papers given before the Students' Section are included, the titles being: Handling Appliances on the Manchester Ship Canal; Ironfoundry Practice, 1919-1939; and Pump Characteristics and Tests. The Annual Report discloses that the affairs of the Association are in a thoroughly healthy state. The Transactions are, as is usual, particularly well indexed.

Steel Conduits and Fittings

The British Standards Institution has just issued the revision of B.S. 31-1933 for steel conduits and fittings for electrical wiring. This revision was undertaken principally with the view to clarifying the position of the lugs relative to the spout outlets in small circular boxes and the table giving the dimensions of the entry bushes has also been slightly amended. Copies of this Standard may be had from the Institution, 28, Victoria Street, S.W.1. (Price 2s. 3d. post free.)

American Production of Steel and Malleable Castings

Statistics compiled by the Department of Commerce, Bureau of the Census, show that the production of malleable iron castings in the U.S.A. for the first six months of 1940 was 221,111 tons, as against 181,276 tons in 1939. The figures relate to 113 plants. The production of steel castings during the same period showed a rise of 51.8 per cent.; in 1940 the production was 320,327 tons, as against 211,051 tons in the first six months of 1939.

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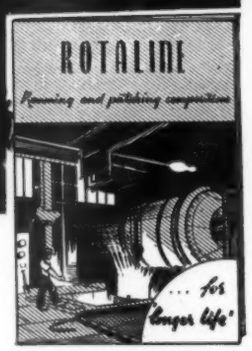

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Raw Material Markets

Heavy foundries continue to be fully employed on work of national importance, and supplies of iron to these concerns are assured by the operation of the priority scheme. Good deliveries are being made, but this can only be done by restricting supplies to ordinary domestic users, such as the light-castings makers, who, however, continue to experience quiet conditions. In some cases light foundries have been able to secure Government orders, but the light-castings trade as a whole is employed at well under capacity levels. It is still not possible to transact as much export business in iron and steel products as is desirable, but progress is being made in this respect, and it is hoped that shipments will be more extensive as soon as the export situation can be reviewed and adjusted in conjunction with the heavy requirements of home consumers.

Pig-Iron

MIDDLESBROUGH—Regular deliveries of foundry iron from the Midlands continue to arrive in the Cleveland district, where consumption is on a heavy scale. Engineering and shipbuilding specifications provide the bulk of the activity among heavy foundries, and order-books are filled well ahead, with the prospect of replacement contracts being available over a long period. Distribution of iron is strictly controlled, and licences have to be obtained for all fresh supplies; the Ministry of Supply is extending licences up to the end of November, and users are now endeavouring to secure their requirements over that period. The blast furnaces in the Cleveland area continue to be mainly concerned with the production of steel-making irons, but if the necessity arose certain furnaces could easily be transferred to the manufacture of foundry iron.

The entire output of East Coast hematite is fully accounted for. Steelworks, especially, are big consumers, while quick disposal is made of surplus material. It is becoming increasingly difficult to acquire hematite for foundry purposes, but the needs of other consumers are being well satisfied, and quite a fair tonnage is being despatched to consumers in Sheffield and the Midlands.

LANCASHIRE—Although some consuming works are not fully employed, notably the jobbing and light-castings foundries, demand for foundry iron is on a heavy scale, and the present state of order-books suggests a continuance of large-scale consumption. Engineering concerns engaged on work for Government departments are unlikely to experience any relaxation in the near future, as there is ample work available to replace contracts which are completed. West Coast hematite is in strong request.

MIDLANDS—High-phosphorus iron is well taken up, but consumers' needs are being satisfactorily catered for, despite the recently increased demand. Bigger tonnages are now in request, as tightness in the supply of low-phosphorus iron and hematite may be alleviated by the incorporation of high-phosphorus iron in engineering foundries' mixtures. Consumption among the makers of light castings is still on a comparatively small scale, owing to the indifferent employment of these works. Some concerns are meeting Government requirements by adapting their plant to the production of machine castings, but business generally is very restricted. Heavy engineers, of course, are right in the thick of Government specifications, and for the most part cannot entertain outside orders.

SCOTLAND—There has been no abatement in the call for foundry iron during the week, and heavy deliveries are being made. Only by careful allocation of supplies can the requirements of priority users be met in full and rationing of other buvers cannot be avoided. Scottish consumers are acquiring their iron from the English Midlands. The position is relieved to some extent by the moderate call from the light-castings trade which continues to be poorly situated; a few makers who are able to cope with Government orders by reason of plant adaptations, are better placed, but the general tone of the trade in the Falkirk district is weak.

Coke

Home consumers' requirements of foundry coke are sufficient to maintain a good rate of activity at the coke ovens, which, of course, are dealing with a considerably reduced export trade. Deliveries are forthcoming satisfactorily, and most of the larger users have plentiful stocks on hand. Ironfounders, especially, are well placed in this respect. For delivery to stations in the Birmingham and Black Country districts, the current quotation of Durham best foundry coke is 55s. 6d. per ton. This price is officially controlled and may be changed at any time. Thus, all contracts contain a rise-and-fall clause.

Steel

The steel industry is now faced with prospects of a substantial increase in the costs of production if the railway companies' case is successful at the inquiry now being made in London. Costs will be raised both by the higher levy on the transport of raw materials and by deliveries of finished material. Producers realise that increases in selling prices are to be avoided as far as is practicable, but they may be left with no alternative. During the past month or so imports of steel semis have been appreciably higher, and the position in this respect is much improved. Billets, sheet bars, etc., bought by the Iron and Steel Corporation in the United States are coming to hand satisfactorily, and re-rollers are no longer incommoded through the lack of adequate supplies. There has been a fairly sharp falling away in the export trade in steel, which is to be regretted, but the more plentiful supply of raw material now coming to hand should facilitate larger shipments before long.

Scrap

Excellent deliveries of iron and steel scrap continue to be made to the consuming works, and in certain districts stocks are being accumulated in the form of dumps placed conveniently to buyers' premises, as many works' yards have become congested, and it is obviously unwise to delay the unloading of railway wagons. The more pressing demands for scrap have been dealt with, and regular supplies are now allowing consumers to maintain full-scale operations. While the position has eased considerably during the past few weeks, no cause for relaxation in the collection campaign can yet be found, as users' yards must be fully stocked before the winter if the situation is to be really satisfactory.

Metals

Some indication of the high rate of copper consumption in this country may be gleaned from the recent British purchases of copper semis and finished products in the United States. Manufacturers at home are expanding their capacity as fast as the necessary plant becomes available, but it is not easy to obtain the machinery required at the present time. Business in the American domestic copper market is very active, and sales have recently been heavy.

The continued disparity between tin prices in London and New York has caused dealers in the United Kingdom to fear that Bolivian producers may exert pressure to have their ores smelted in the United States instead of in this country. It must be admitted that if the disparity widens to any extent the possibility of the building up of an American tin refining industry on a fairly large scale will be enhanced. American consumers are, of course, vitally concerned with the present situation, and may favour the project as a precaution against supplies from the United Kingdom being cut off or Japanese action affecting shipments from the Straits. It is also suggested that it would be advisable to counter Nazi designs on the domination of South American States by the erection of smelters in the United States. Tin prices on the London Exchange have further declined this week. Export licences are being granted on a comparatively small scale, thus restricting smelters' outlets. It should also be borne in mind that tin is one of the few commodities excluded from the war risks insurance scheme and, as is only natural in existing circumstances, dealers are disinclined to take in warrants.

The total visible supply of tin on August 31, according to Mr. W. H. Gartsen (Henry Rogers, Sons & Company) was 32,250 tons, against 32,659 tons on July 31. The carry-over in the Straits Settlements was 2,172 (2,819) tons, while the carry-over at principal European smelters was 3,449 (2,750) tons.

London Metal Exchange tin prices this week have been as follow:—

Cash—Thursday, £255 5s. to £255 15s.; Friday, £256 to £256 5s.; Monday, £250 to £251; Tuesday, £249 to £249 10s.; Wednesday, £248 to £249.

Three Months—Thursday, £256 15s. to £257 5s.; Friday, £257 to £257 5s.; Monday, £253 to £253 10s.; Tuesday, £251 10s. to £252; Wednesday, £251 to £251 10s.

Deliveries of spelter to priority consumers remain fully adequate to meet the strong demand, and metal is available for the manufacture of products for the export market. Consumption in the United States is steadily rising under the influence of the needs of the defence programme, and stocks are reported to be at a lower level than for some years past. It has been suggested that larger imports of zinc concentrates may have to be made from Canada and Mexico; if this is so it will provide relief for Mexican producers, whose outlets have been restricted for some time past. Production of zinc in America during August amounted to 49,900 tons, compared with 52,000 tons in July. Deliveries totalled 64,100 tons, compared with 57,700 tons, while stocks at the end of August aggregated 44,700 tons, compared with 59,100 tons at the end of July.

The lead supply position is very satisfactory, not only in connection with essential needs, but also with regard to consumers' requirements generally.

Research and Developments In Cast Metals

(*Continued from page* 170.)

articles now made by the standard practices of melting, casting and fabricating. In some cases it is a mere matter of substitution, while in others the powdered metal articles are supreme.

Powder metallurgy is proving useful in some phases of bearing manufacture. Oil-less bushings with uniform porosity are being used widespread. Soon a new type of copper-lead bearing made by powder metallurgy processes from chemically pure constituents uniformly distributed throughout the alloy will be available. This bearing will doubtlessly challenge the present position of the cast, copper-lead bearings and may eventually supplant the latter.

Some good is bound to come to the casting industry as a result of this intensive study now being given to powder metallurgy processes. Leach points out[8] that it is possible the study of powder metallurgy will give physical metallurgists a better opportunity to observe phenomena that affect the melting, casting and fabrication of metals and alloys with the reasonable expectation that valuable information may be obtained leading to improvements in standard metallurgical practices.

In conclusion the casting industry has conducted endless experimentation of a practical nature. There has been, however, an almost complete absence of fundamental research. The production of good castings represents, as Melmoth stated,[9] a combination of practical and theoretical factors involving great difficulty in their elucidation and understanding. As the general attitude toward scientific development becomes more sympathetic and foundrymen begin to apply science more generally, they can expect a proportionate upturn in progress in the castings industries.

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CAPACITY 60 tons per hour
with
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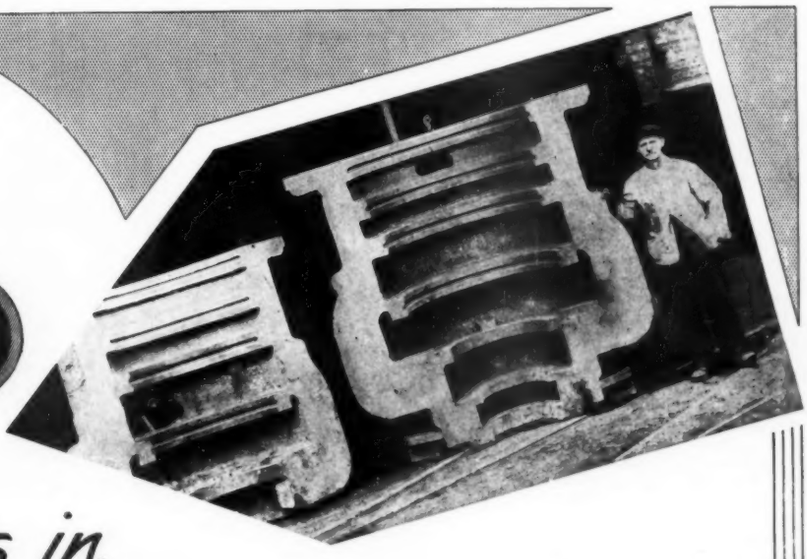

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Electrolytic	62	0	0
High-grade fire-refined ..	61	10	0
Fire-refined of not less than 99.7 per cent.	61	0	0
Do., do., 99.2 per cent. ..	60	10	0
Black hot-rolled wire rods..	65	10	0

TIN

	£	s.	d.
Standard cash	248	0	0
Three months	251	0	0
Settlement	249	0	0
Official average Cash, Aug.	262	12	$4\frac{7}{11}$
Do. Three Months, Aug.	263	1	$1\frac{7}{11}$
Do. Settlement, Aug. ..	262	10	$8\frac{4}{11}$

SPELTER*

	£	s.	d.
G.O.B. (foreign) (duty paid)	25	15	0
Do. (domestic)	26	10	0
" Prime Western " ..	26	10	0
Refined and electrolytic ..	27	5	0
Not less than 99.99 per cent.	28	15	0

LEAD*

	£	s.	d.
Good soft pig lead (foreign) (duty paid)	25	0	0
Do., do., (Empire and domestic)	25	0	0
English	26	10	0
Sheets, home	34	10	0
Do. export, f.o.b. ..	30	0	0
Pipes, home	34	0	0
Do. export, f.o.b. ..	30	10	0
Tea lead (nom.)		—	

ALUMINIUM

Ingots	£110
Wire, 10g.	nom.
Sheets	nom.
Circles, 20/24g.	nom.

ZINC SHEETS, etc.

	£	s.	d.
Sheets, 10g. and thicker, ex works	39	2	6
Rolled zinc (boiler plates), ex works	37	2	6
Zinc oxide (Red Seal), d/d buyers' premises ..	28	7	6

ANTIMONY

	£	s.	d.
English, 99%	90	0	0
Foreign Regulus, duty paid .. 90 0 0 to	92	0	0
Chinese, prompt shipment, c.i.f. .. 79 0 0 to	82	0	0

QUICKSILVER

	£	s.	d.
Quicksilver, ex-w'hse London	54	10	0

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten 3s. 0d.
Finished bars, 18% tungsten 3s. 10d.
Finished bars, 22% tungsten 4s. 4d.
Per lb. d/d buyers' works.

NICKEL SILVER, etc.

	Per lb.
Ingots for raising ..	9d. to 1/3
Rolled—	
To 9 in. wide ..	1/3 to 1/9
To 12 in. wide ..	1/3½ to 1/9½
To 15 in. wide ..	1/3½ to 1/9½
To 18 in. wide ..	1/4 to 1/10
To 21 in. wide ..	1/4½ to 1/10½
To 25 in. wide ..	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
to 10g.	1/6½ to 2/1½
with extras according to gauge.	
Special 5ths quality turning rods in straight lengths, 1/5½ upwards.	

Maximum prices per long ton delivered to buyers' premises.

FERRO-ALLOYS AND STEEL-MAKING METALS

(all prices nominal)

	£	s.	d.
Ferro-silicon—			
25%	18	10	0
45/50%	21	10	0
75%	31	0	0
Ferro-vanadium—			
35/50%	15/6 lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free ..	6/- lb. Mo.		
Ferro-titanium—			
20/25% carbon-free ..	1/9 lb.		
Ferro-tungsten—			
80/85%	5/1 lb.		
Tungsten metal powder—			
98/99%	5/2½ lb.		
Ferro-chrome—			
2/4% car.	—		
4/6% car.	47	0	0
6/8% car.	47	0	0
8/10% car.	—		
Ferro-chrome—			
Max. 2% car.	—		
Max. 1% car.	—		
Max. 0.5% car. ..	—		
70% carbon-free ..	—		
Nickel—99.5/100%	£190 to £195		
"F" nickel shot	175	0	0
Ferro-cobalt, 98/99% ..	8/9 lb.		
Metallic chromium—			
96/98%	3/9 lb.		
Ferro-manganese—			
76/80% loose	18	0	0
76/80% packed	19	10	0
Metallic manganese—			
94/96% carbon-free ..	1/9 lb.		

Per ton unless otherwise stated, basis 2-ton lots, d/d Sheffield works.

SCRAP*

	£	s.	d.	£	s.	d.
SOUTH WALES—						
Short heavy steel, not ex. 24-in. lengths.. ..	3	16	6 to	3	19	0
Heavy machinery cast iron		4	6			6
Ordinary heavy cast iron		4	1			6
Cast-iron railway chairs		4	6			6
Medium cast iron ..		3	17			9
Light cast iron		3	13			0
MIDDLESBROUGH—						
Short heavy steel	3	14	3 to	3	16	9
Heavy machinery cast iron		4	11			3
Ordinary heavy cast iron		4	8			9
Cast-iron railway chairs		4	8			9
Medium cast iron ..		3	19			0
Light cast iron		3	14			0
BIRMINGHAM DISTRICT—						
Short heavy steel	3	9	3 to	3	11	9
Hematite ingot mould		5	10			9
Heavy machinery cast iron		4	11			9
Ordinary heavy cast iron		4	7			0
Cast-iron railway chairs		4	7			0
Medium cast iron ..		3	19			9
Light cast iron		3	14			9
SCOTLAND—						
Short heavy steel	3	14	0 to	3	16	6
Heavy machinery cast iron		4	13			9
Ordinary heavy cast iron		4	8			9
Cast-iron railway chairs		4	13			9
Medium cast iron ..		3	16			9
Light cast iron		3	11			9

* Delivered free to consumers' works in England and Wales. For deliveries of cast-iron scrap free to consumers' works in Scotland, the above prices less 2s. per ton, but plus actual cost of transport or 6s. per ton, whichever is the less. All prices: Plus 2½ per cent. dealers' remuneration: 50 tons and upwards over three months 2s. 6d. extra

PIG-IRON*

N.E. COAST (d/d Tees-side area)—	
Foundry No. 1	123/-
" No. 3	120/-
" No. 4	119/-
Forge No. 4	119/-
Hematite No. 1	131/-
Hematite M/Nos.	130/6
N.W. COAST—	
Hem. M/Nos. d/d Glas. ..	131/-
" d/d Birm.	142/6
MIDLANDS (d/d Birmingham dist.)—	
Staffs No. 4 forge	121/-
" No. 3 fdry.	122/-
Northants forge	118/6
" fdry. No. 3 ..	119/6
" fdry. No. 1 ..	122/6
Derbyshire forge	121/-
" fdry. No. 3 ..	122/-
" fdry. No. 1 ..	125/-
Phosphorus 0.5% to 0.75%	129/6
Phosphorus 0.1% to 0.5%	132/6
SCOTLAND—	
Foundry No. 1, Grangemouth	119/9
" No. 3, Grangemouth	117/3
Cleveland No. 3, Glasgow	123/-
" " Falkirk ..	120/-
Scottish hem. M/Nos. d/d..	131/-
SHEFFIELD (d/d district)—	
Derby forge	118/6
" fdry. No. 3 ..	119/6
Lincs forge	118/6
" fdry. No. 3 ..	119/6
W.C. hematite	136/6
LANCASHIRE (d/d eq. Man.)—	
Derby fdry. No. 3 ..	125/-
Staffs fdry. No. 3	125/-
Northants fdry. No. 3 ..	123/6
Cleveland fdry. No. 3 ..	125/-
Cylinder and Refined Irons	
North Zone..	168/-
South Zone..	170/6
Refined Malleable	
Birmingham and S. Staffs ..	165/6
Cold Blast	
South Staffs	217/-

* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms and Slabs.

	£	s.	d.
BASIC:			
Soft, u.t., 100-ton lots ..	10	10	0
Tested, up to 0.25% C. ..	10	15	0
Tested, 0.25 to 0.33% C.	10	17	6
Tested, 0.33 to 0.41% C...	11	0	0
Hard (0.42 to 0.60% C.)..	11	17	6
" (0.61 to 0.85% C.)..	12	7	6
" (0.86 to 0.99% C.)..	12	17	6
" (1% C. and up) ..	13	7	6
Silico-manganese	14	5	0
Free-cutting	12	10	0
SIEMENS MARTIN ACID			
Up to 0.25% C.	13	15	0
Case-hardening	14	12	6
Silico-manganese	14	10	0

Billets, Blooms and Slabs for Forging and Stamping.

Basic soft, up to 0.25% C. ..	12	2	6
Basic hard, 0.41 to 0.60% C.	12	10	0
Acid, up to 0.25% C. ..	14	5	0

Other Semi-products, etc.

Tin bars	10	7	6
Sheet bars	10	7	6
*Wire rods, soft basic ..	15	4	0
" hard basic ..	18	12	6
" free-cutting ..	17	12	6
" acid	22	3	6

* Subject to rebate.

FINISHED STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel bars, sections, plates joists and hoops is obtainable in the home trade under certain conditions.]

	£	s.	d.
Plates, ship (N.E. Coast) ..	14	3	0
Boiler plts. (N.E. Coast) ..	15	0	6
Chequer plts. (N.E. Coast)	15	13	0
Angles, over 4 un. ins. ..	13	13	0
Tees, over 4 un. ins. ..	14	13	0
Joists, 3 in. × 3 in. and up	13	13	0
Rounds and squares, 3 in. to 5½ in.	14	13	0
Rounds under 3 in. to ⅛ in. (untested)	15	8	6
Flats—over 5 in. wide ..	13	18	0
" 5 in. wide and under ..	15	8	6
Rails, heavy, f.o.t. ..	12	15	6
Hoops	16	3	6
Black sheets, 24 g. (4 t. lots)	19	7	6
Galv. cor. shts. (")	22	12	6
Galv. flat shts. (")	23	2	6
Galv. fencing wire, 8g. plain	24	7	6

FINISHED IRON

	£	s.	d.
CROWN IRON:			
England and Wales ..	15	2	6
Scotland	15	2	6
Ireland, f.o.q.	15	15	0
No. 3 BARS:			
England and Wales ..	12	5	0
Scotland	13	7	6
Ireland, f.o.q.	12	17	6
No. 4 BARS:			
England and Wales ..	12	15	0
Scotland	13	12	6
Ireland, f.o.q.	13	7	6
STRIP:			
England and Wales ..	16	10	0
STAFFS MARKED BARS, f.o.t...	18	0	0

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated, August 13, 1940.

	Dols.
No. 2 foundry, Phila.	24.84
No. 2 foundry, Valley	23.00
No. 2 foundry, Birm.	19.38
Basic, Valley	22.50
Malleable, Valley..	23.00
Grey forge, Valley	22.50
Ferro-mang., seaboard	120.00
O.-h. rails, h'y, at mill	40.00
Billets	34.00
Sheet bars	34.00
Wire rods	2.00
	Cents.
Iron bars, Chicago	2.25
Steel bars	2.15
Tank, plates	2.10
Beams, etc.	2.10
Skelp, grooved steel	1.90
Steel strip	2.10
Steel sheets	2.10
Sheets, galv., No. 24	3.50
Wire nails	2.55
Plain wire	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens)

Welsh foundry	42/6 to 44/-
" furnace	31/6 to 33/-
Durham foundry	39/6
" furnace	33/5
Scottish foundry	42/6 to 47/6
" furnace	31/6

TINPLATES

f.o.b. Bristol Channel ports

I.C. cokes	20 × 14 per box ..	28/-	
"	28 × 20 " ..	56/-	
"	20 × 10 "	39/6 to	40/6
"	18⅞ × 14 " ..	29/-	
C.W.	20 × 14 " ..	27/-	
"	28 × 20 " ..	55/-	
"	20 × 10 " ..	39/-	
"	18⅞ × 14 " ..	28/-	

NON-FERROUS SCRAP

(Official Maximum Prices, per ton ex Works.)

	£	s.	d.
Bright untinned copper wire, in crucible form or in hanks	57	10	0
No. 1 copper wire	57	0	0
No. 2 copper wire	55	10	0
Copper firebox plates, cut up	57	10	0
Clear untinned copper, cut up	56	10	0
Braziery copper	53	10	0
Q.F. process and shell-case brass, 70/30 quality, free from primers	49	0	0
Clean fired 303 S.A. cartridge cases	47	0	0
70/30 turnings, clean and baled	43	0	0
Brass swarf, clean, free from iron and commercially dry	34	10	0
New brass rod ends, 60/40 quality	38	10	0
Hot stampings and fuse metal, 60/40 quality	38	10	0
Admiralty gunmetal, 88-10-2, containing not more than ½ per cent. lead or 3 per cent. zinc, or less than 9½ per cent. tin	72	0	0

NEW BRASS TUBES, etc.

	Per lb.
Solid drawn tubes	13½d.
Brazed tubes	15½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	8½d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	9½d.
Yellow metal rods	8½d.

COPPER TUBES, etc.

Solid drawn tubes	14½d.
Brazed tubes	14½d.
Wire	9½d.

PHOSPHOR BRONZE

	Per lb. basis
Strip	13½d.
Sheet to 10 w.g.	13½d.
Wire	15½d.
Rods	15½d.
Tubes	20½d.
Castings	17d.

Delivery 3 cwt. free.
10% phos. cop. £35 above B.S.
15% phos. cop. £40 above B.S.
Phosphor tin (5%) £40 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

AVERAGE MONTHLY PRICES OF STEEL RAILS

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1925	9 0 0	9 0 0	9 0 0	9 0 0	8 15 0	8 10 7½	8 10 0	8 10 0	8 10 0	8 4 0	8 0 0	8 0 0	8 11 7
1926	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 10 0	8 3 11
1927	8 10 0	8 10 0	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 3 0	8 5 0	8 5 0	8 4 10
1928	8 5 0	8 5 0	8 5 9	8 6 3	8 6 3	8 6 3	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 7 9½
1929	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0
1930	8 0 0	8 10 0	8 10 0	8 10 0	8 10 0	9 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0
1931	8 9 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 8
1932	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1933	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1934	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1935	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1936	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6
1937	8 7 6	8 7 6	8 7 6	8 7 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	9 10 10
1938	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6
1939	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 3 0	9 3 0	10 3 0	10 3 0	9 11 0
1940	10 3 0	11 3 0	11 3 0	11 3 0	11 3 0	11 3 0	12 15 6	12 15 6	—	—	—	—	—

AVERAGE MONTHLY PRICES OF EAST COAST HEMATITE MIXED NUMBERS AT MIDDLESBROUGH*

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1925	87 6	85 9	84 7½	82 6	80 10½	79 3	77 1½	75 7½	75 0	74 3½	74 9	76 9	79 5½
1926	77 3	77 9	77 3½	76 3	77 4½	78 0	79 8½	81 9	83 4½	87 7½	92 6	90 5½	81 7½
1927	90 0	90 0	86 3½	83 1½	80 6	78 0	78 6	75 4½	75 0	72 9	71 9	71 1½	79 2½
1928	90 7½	90 7½	90 9	70 0	70 0	69 3	68 7½	69 2	70 0	70 0	70 3	71 6	89 9½
1929	71 6	72 0	73 6	74 0	74 0	74 1½	74 9	75 6	76 1½	76 8½	78 1½	79 0	74 1½
1930	78 2½	78 0	76 9	75 0	74 0	72 7½	71 0	71 0	71 0	71 0	70 10½	70 4½	73 3½
1931	70 0	69 0	68 0	66 8½	65 1½	63 4½	62 9	61 1½	65 0	65 0	65 0	65 0	65 0
1932	64 10	64 3	63 6	63 6	63 6	62 7½	62 0	60 6	60 0	59 3	59 0	59 0	61 10
1933	59 0	59 0	59 0	59 0	59 0	59 0	59 0	59 0	59 3	60 7½	62 6	62 6	59 8½
1934	62 6	65 0	67 6	67 6	67 6	67 6	67 6	67 6	68 0	68 6	68 6	68 6	67 2
1935	68 6	68 6	68 6	68 6	68 6	68 6	69 7½	70 6	70 6	70 6	70 6	70 6	69 5½
1936	70 6	75 3	76 6	76 6	77 4	80 0	85 0	85 0	85 0	85 0	85 0	85 0	80 6
1937	97 6	97 6	97 6	97 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	114 2
1938	132 6	132 6	132 6	132 6	132 6	132 6	132 6	132 6	132 6	132 6	132 6	132 6	132 6
1939	120 0	120 0	120 0	120 0	120 0	120 0	115 0	115 0	115 0	115 0	124 0	124 0	119 0
1940	124 0	127 0	127 0	127 0	127 0	127 0	130 6	130 6	—	—	—	—	—

* Since March, 1934, delivered works; previously f.o.t. furnaces. NOTE.—Prices of hematite have since July 1, 1936, been subject to a rebate of 5s. under certain conditions.

WILLIAM JACKS & COMPANY
LIMITED
WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.
13, RUMFORD STREET, LIVERPOOL.

PIG

IRON

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS
COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY
LIMITED
CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2
ZETLAND ROAD, MIDDLESBROUGH.

SITUATIONS VACANT AND WANTED

FIRST-CLASS FOUNDRY MANAGER, age 42, long and varied experience, specialist in non-ferrous metals, successful organiser, seeks post; highest references.—Box 458, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOUNDRY on N.E. Coast requires a Manager, with practical and commercial experiences. For a suitable man possessing push and personality, and experience in Chilled work, prospects are excellent.—Applications (which will be treated in the strictest confidence), giving age, experience in Foundry engineering and commercial practice, along with other qualifications, to Box 466, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

TIME AND MOTION STUDY.—Young man required at a Foundry in the West Riding. Preferably with some previous experience and not liable for Military Service. State qualifications and salary required.—Apply Box 462, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

WANTED for one of the largest steel foundries in the country, a General Foreman to take charge of all moulding and coremaking. State age, education, experience and salary required to Box 464, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road. High Wycombe.

FOREMAN or Assistant seeks re-engagement; experienced general engineering up to 10 tons. Repetition, also non-ferrous including manganese bronze. Age 34. Keen and energetic. Technically trained. First-class references.—Box 452, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

EMPLOYMENT REGISTER.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

MANAGER or Assistant Foundry Manager desires re-engagement; Light Alloys to Air Ministry Specs.; Alloy Cast Iron; Grey Iron; green sand; dry sand. Jobbing and machine moulding; pattern shop. (391)

MALLEABLE and grey cast iron foundry manager seeks re-engagement similar position or as consultant to firm starting or developing malleable cast iron. First-class record. (370)

BUSINESS FOR SALE

FOR SALE.—Small Ironfoundry in North Midlands, specialising in Grey Iron Castings up to 10 cwts. Going concern. Owner retiring.—Box 440, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

MACHINERY

WANTED, 8/12-ton Jolt Machine, Jackman type, 20-in. to 30-in. bore.—Full particulars to Box 446, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

FOR SALE, one Titan Cupola, 27 ft. high by 3 ft. 6 in., having melting capacity of 3 to 4 tons of metal per hour when lined down to 30-in. internal diameter, complete with fan. —Apply Box 460, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

PNEULEC ROYER Sand Mixing Machine (No. 2) for sale; had little use and in first-class condition.—Box 444, Offices of THE FOUNDRY TRADE JOURNAL, 3, Amersham Road, High Wycombe.

MACHINERY—*Continued*

6 ALLDAY'S No. 0 Empire Oil Burners for sale.—LANDSEER-BAILEY, 385, Garratt Lane, London, S.W.18. Batt. 3018.

THOS. W. WARD, LTD.

16 BABCOCK & WILCOX WATER TUBE BOILERS, heating surfaces 4,410 to 5,540 sq. ft.; pressure 200 lbs. per sq. in.; with ECONOMISERS MECHANICAL STOKERS.
CROSS TUBE BOILER, 4 ft. by 2 ft. 3 in. by 60-lbs. w.p.
COCHRAN BOILER, 7 ft. 6 in. by 3 ft. 3 in., gas fired, w.p. 100 lbs.

Write for "Albion" Catalogue

ALBION WORKS, SHEFFIELD

'Grams: "Forward." 'Phone: 26311 (15 lines).

POSITIVE PRESSURE BLOWERS, Alldays Empire, Two No. 2. One No. 4; also 2-h.p. R.I., 2- and 3-h.p. Squirrel Motors, 210 v., 50 cy., 1 ph.; 3-Wheel Star Bandsaw.—BAILEY, 385, Garratt Lane, London, S.W.18. Batt. 3018.

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & CO. LTD., Station Works, Ecclesfield, Sheffield.

CUPOLAS

2 ft. 6 in. dia., 15-cwt. per hr. Cupolette.

PNEUMATIC MOULDING MACHINES

Macdonald Jolter, table 72 in. by 54 in.
Tabor 16-in. Shockless, table 72 in. by 48 in.
Tabor Portable Shockless Rollover, table 40 in. by 30 in.
Tabor ditto, table 27 in. by 20 in.
Tabor 21 in. by 16 in. squeeze.
Zimmerman Type R.P.W. 2 Jolt Squeeze turnover, table 36 in. by 20 in.
Mumford Type (Jackman) Swing Headpress, 13 in. by 15 in. and 14 in. by 16 in.
Mumford Pneumatic Core Jolters having 15-in. by 20-in. and 12-in. by 12-in. tables.
Britannia No. 1 "Coventry" Pneumatic Turnover Jarr Ram, table 30 in. by 28 in.
50 Air Compressors; 500 Electric Motors, Dynamos, etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD, LANGLEY,
Nr. Birmingham.
'Phone: Broadwell 1359.

MISCELLANEOUS

"A STUDY IN ECONOMY"
ACTUAL MANUFACTURES
BY USING OUR

Foundry Blackings, Facings, Parting Powder, Core Gum, Terra Flake, Talc Coal Dusts, Ganister, Ceylon Plumbago (Imports direct). We definitely help to produce perfect Castings. Only the best minerals used in the making. A trial order will convince users of their economic value.

JOHN & C. DURRANS,
PENNINE WORKS, HAZLEHEAD,
NEAR SHEFFIELD.

Telephone: 128 Penistone. Telegrams: Facings, Penistone.

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